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ABSTRACT

This report describes a program designed to improve science achievement among students in grades 4-6 in a New Hampshire school. The areas of improvement included physical, earth, and life sciences. Analysis of the problem indicated a need for improved teaching techniques and for additional materials related to the instructional strategies. The interventions included inservice experiences to improve the teachers' abilities to use manipulative materials, scientific technique, and concept verbalization. The teachers were introduced to the Investigation Colloquium Method (ICM) of instruction and to the use of new materials purchased for the intervention. Achievement was measured by pretest and posttest assessment which was based on the end-of-chapter and supplemental tests provided in the textbook. The performance objective for all grades was to improve the average pretest score in the three areas of science by 30 percentage points on the posttest. The performance goals were met or exceeded for all areas of science at each grade level. Consistent use of a prescribed instructional strategy and materials by the target group of teachers was seen as a significant factor in student achievement. The appendices contain test materials and science objectives for the units for each grade. (Author/YP)

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IMPROVING STUDENT SCIENCE ACHIEVEMENT IN GRADES 4-6 THROUGH HANDS-ON MATERIALS AND CONCEPT VERBALIZATION

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by

* Roger C. Brooks

Submitted in partial fulfillment of the requirements of the National Ed.D Program for Educational Leaders

Nova University

Advanced Practicum Report
Maine Cluster
Submitted: September, 1988

* Principal
Beaver Meadow Elemenatary School
Concord, New Hampshire
(603) 225-0853

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AUTHOR: Roger C. Brooks
DATE: September, 1988
CLUSTER: Maine
PRACTICUM: Advanced

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The performance goals were met or exceeded for all areas of science at each grade level. Consistent use of prescribed instructional strategy and materials by the target group of teachers was seen as a significant factor in student achievement.

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Chapter 1

BACKGROUND

School and Community Setting

The city of Concord, New Hampshire is situated 42 miles north of Massachusetts and midway between Maine and Vermont. Concord is the capital of the State of New Hampshire and has a population of 33,000. It is also the center of the political, financial, commercial, industrial and educational activities in the area. The major employers in Concord include the State government, Chubb-Life America and Blue Cross Blue Shield Insurance companies, and several small manufacturing enterprises. The tax rate in Concord is set annually by the total assessments of three independent and autonomous elected bodies: a three-member Board of County Commissioners, a 15-member City Council and a nine-member Board of Education. Each member of the Board of Education serves a three-year term with one third of the Board standing for election every November.

Despite its limited tax base, due to the large amount of State-owned property, Concord "maintains an attractive educational climate." (Daniels et al. 1985:3). Taxpayers demonstrate their support by consistently allocating reasonable expenditures for teachers salaries, sufficient equipment and supplies for instruction, and adequate facilities for its student population. With a pay scale higher than that of the surrounding areas, teaching vacancies have been filled rapidly. Administrators report that they have many good candidates from which to choose. Although the fact that Concord has one of the highest tax rates in the State was a concern, it did not spawn full-scale taxpayer revolts experienced by many communities.

Table 1

Elementary School Enrollment Report Summary-
Concord School District-Fall 1987

School	Grade Levels	Total
Beaver Meadow	K- 6	450
Broken Ground	4- 6	320
Conant	K- 6	470
Dame	K- 3	390
Dewey	K- 2	150
Eastman	K -3	110
Kimball	2- 6	250
Rumford	K- 6	200
Walker	K- 6	200
Elementary Total	K- 6	2,540

In the fall of 1987, the Concord School District had 9 elementary schools, one junior high school, and one high school. According to the September, 1987 enrollment figures, the District had over 4,800 students enrolled with over 2,500 of that total in the elementary grades (Table 1). The elementary schools differed in size, character and socio-economic status of population. Two schools, Rumford and Walker, served the lower income areas of the city. Broken Ground, Dame and Beaver Meadow served the middle income sections, while Conant, Dewey, Eastman, and Kimball served the wealthier areas of the city. Most of the schools were built in the 1920s, with Conant added in 1954, Broken Ground in 1974 and Beaver Meadow in 1987.

There were 350 teachers in Concord Schools, 190 of whom taught elementary school students. Included in the total were classroom teachers, guidance counselors, speech and language teachers, learning disabilities, occupational and physical therapists. Art, music and physical education teachers were also included. At the elementary level, there were approximately 40 aides, including those for individual students, library, cafeteria and playground. The district provided special programs for the gifted and talented,

emotionally disturbed, learning disabled, mentally retarded, speech and language and physically handicapped.

The Concord Schools were led by a nine-member Board of Education, a superintendent, and two assistant superintendents, one of whom directs the curriculum program and the other oversees finance. Other administrative staff included a director of special education, a director of maintenance and transportation, seven elementary principals, a junior high principal with two assistant principals and a senior high principal, also with two assistant principals.

School Characteristics

Beaver Meadow Elementary School was the subject of the study. There were 18 classroom teachers. The support staff of 30 included part-time art, music and physical education teachers, a secretary and the principal. The classrooms were self-contained and included a transition classroom between kindergarten and first grade for students who are developmentally young. Of the classroom teachers, one had thirty credits above a Masters degree and fourteen had Masters. Of the three remaining teachers who had Bachelor degrees, two were enrolled in Masters programs.

Beaver Meadow School is located in an area of the city which had experienced considerable growth. According to the City of Concord Planning Department's figures, nearly 500 new housing units were built before the fall of 1987, and 1450 more units were in some stage of the planning or building process. Such growth, coupled with the delapidated state of an existing school, resulted in Beaver Meadow being built during the period from December 1985 to February 1987. Originally built for 350 students, construction on an additional eight classrooms began two weeks after the students occupied the building in

March of 1987. With the growth in the number of housing units had come a growth in the student population as well. For the previous 15 years, the old school, Garrison, had a population of about 275. Most of those students came from the homes of the lowest socio-economic status in the city. The school experienced the highest student turn over rate and the highest percent of handicapped students in the city. When interest rates fell in the early 1980's, condominiums, apartments and single family homes began to be built in the area. With the new homes, came families from a different socio-economic status. More middle and upper middle income families who could afford the $100,000 to $180,000 homes began moving into the area. In a study completed in 1985, 19 percent of the parents at Garrison School fell below the poverty level compared to 7 percent for the city (Brooks, 1987). In 1987, the poverty level figures and the number of single family homes in the Beaver Meadow School population were similar to those of the rest of the city.

National Status

In studies of education during the 1980's decade, science was chosen as an area of concern. Some had claimed that deficiencies in the science curriculum had produced high school graduates who are scientifically and technologically illiterate (Koballa, 1985). Others had cited evidence that our students had not been taught the knowledge and the skills to be responsible citizens and, as a result, our country had lost its economic competitive edge (Hurd, 1986).

International studies provided additional evidence that students in the United States did not achieve as well in science as students in other countries. For instance, in the Second International Science Study in 1983, our students performed at or below the same level attained in 1970 when the first study was completed. What was more disappointing was the fact that students in England,

Japan and six other countries out-performed our top students, who were taking advanced courses in physics, chemistry, and biology (Rothman, 1987).

If the criticism of the science curriculum and instruction was valid, then some restructuring of science education was in order. Before any restructuring could occur, several key questions needed to be answered about what were the purposes of science education, what subject matter was worth studying and what were the best ways to accomplish curriculum goals. Of primary concern was what kind of job were we doing in Concord? What were the strengths and weaknesses of our science program? How much did the national concerns apply to Concord Schools? After a review of the curriculum in Concord, if deficiencies were found, what were the appropriate remedies?

In the late 1950's and early 1960's, as a response to the launching of the first Russian satellite, Sputnik 1, science curricula received its last broad revision. At the elementary and secondary level, the education community responded by introducing new programs which were based on the philosophy that if the student could learn to think like a scientist, science would be more interesting. The instructional strategy was to teach content through the processes of inquiry and experimentation, the way real scientists do. There was evidence that the student who was exposed to the method does benefit from it. Studies have shown that when students were taught by the process method, both achievement and student attitude improved (Kyle, 1985). However, when these programs began to be implemented at the elementary level, the mood of the public changed from being supportive of innovative science programs to questioning whether the commitment of resources was worth the effort. As a result, colleges and high schools relaxed science requirements for graduation and as the director of the National Science Teachers Association, Marcuccio said "...the pressure was off elementary schools, too. Teachers who didn't feel

comfortable teaching science were free to let it slide." (as cited by Cramer, 1987: 6). Textbook publishers found a limited market for elementary materials. Marcuccio added:

> Science education became hopelessly fragmented as educators turned their attention to the three R's, the back-to-basics movement, the middle school phenomenon, tight budgets, and declining enrollments. Who had the time? Who had the money? (as cited by Cramer, 1987:6)

In a report released in 1983, the National Science Board found science instruction in elementary schools to be disorganized and inadequate. It estimated that 1.2 million elementary teachers would have to be retrained to adequately teach the subject and that fewer than 2 percent of elementary students receive a solid science education. (Cramer, 1987) In a review of research, Harms and Yager, as cited by Kyle, further documented the shift in the elementary classrooms. They concluded that 90 percent of the teachers used textbooks 95 percent of the time; that 90 percent of the teachers stressed goals aimed simply at preparing the students for the next level of instruction; there was virtually no evidence of science teaching by direct experience; nearly all of the teaching was done by lecturing; and the use of question and answer periods with memorization of the correct answers was the goal (Kyle, 1985).

In New Hampshire, the State Department of Education released the results of a survey of principals and teachers which was designed to assess the status of science in relation to other core subjects (New Hampshire 1983). The report indicated that the amount of time and financial resources devoted to science varied greatly among schools. In addition, the results indicated that teachers in the State devoted less time for preparation and instruction in science than for math, reading, language arts or social studies. In the report, the writers concluded that science education as practiced in the State, could not be considered a "basic".

In January 1987, in response to the criticism of elementary science

instruction, the National Science Foundation awarded $6.6 million to create a more consistent national curriculum. Included in the grants were $2.2 million to the Education Research Centers to develop science units in grades 4-6 with publication rights to the National Geographic Society; $2.3 million to the Biological Science Curriculum Study to develop new science and new health curriculum in grades K-6; and, $2.1 million to the Education Development Center to create a life, physical, and earth science curriculum geared to urban elementary school students and teachers. (Goldberg, 1987)

If the criticism of science curricula and instructional methods was valid, then some change in the way science instruction was delivered in Concord Schools was in order. Before such a change could take place, some basic questions needed to be answered. Specifically, what was the condition of science education at Beaver Meadow School? Did any of the national concerns have relevance in Concord, New Hampshire? If the answer to any of the questions was "yes", what remedies existed to correct the deficiencies?

Chapter 2

IDENTIFICATION AND EVIDENCE OF THE PROBLEM

General Statement

In 1985 and 1986, students who attended Garrison School, and later attended Beaver Meadow Elementary School, received lower than anticipated scores in the fourth and sixth grade science subtest of the California Achievement Test (CAT). In grade 6, district test scores reflected similar results in each of the two years.

In 1983 a survey designed to assess teacher needs in science, and in 1986 a survey designed to assess teacher needs in all subjects reflected district teachers' frustration with the existing science curriculum. The surveys' results indicated that only 35 percent of the curriculum objectives required at each grade level were being taught. Furthermore, teachers in the intermediate grades reported that they were spending 20 to 80 minutes less teaching Science than the 150 minutes per week recommended by the New Hampshire State Department of Education. In addition, the teachers stated that much of the curriculum materials in science were either inappropriate or unused.

Detailed Documentation

In 1985, the State of New Hampshire instituted mandatory use of the California Achievement Tests (CAT) and the Cognitive Skills Inventory (CSI) during two weeks in October in grades 4, 8, and 10. In Concord, the tests were also administered to grade 6. The CAT provided the State Board of Education, local school districts and the public a common measure of achievement in New Hampshire. The CSI is a measure of individual student ability. When used in

conjunction with each other, McGraw-Hill, the test publishers, can project an anticipated score for the individual, classroom, school, district or state taking the test. According to the publishers,

> Anticipated achievement scores make it possible to estimate the extent to which an individual student is achieving in accordance with expectations for comparable students. A student's anticipated achievement score represents an estimate of the average score for students of similar age, grade and academic aptitude. Anticipated achievement scores may be computed in ...national percentiles (AANP)(CTB-McGraw Hill, 1986:79).

CTB-McGraw Hill defines AANP as

> ...the percentage of students in a norm group whose scores fall below a given student's scale score. For example if a student's scale score converts to a national percentile (NP) rank of 71, this may be interpreted to mean that the student scored higher than approximately 71 per cent of the students in the norm group. (1986:77).

By comparing the actual scores with the anticipated performance scores weaknesses in individual students, class, school, and district were identified.

Table 2

Comparison of NP And AANP CAT Results
Concord District-Grade 6, 1986-87

Test	Obtained	Anticipated
Reading Vocabulary	70.3	59.9
Reading Comprehension	69.6	58.6
Language Mechanics	51.3	59.7
Language Expression	57.7	57.7
Math Computation	53.2	53.2
Math Concepts & Applications	66.2	58.2
Word Analysis	52.9	49.1
Spelling	57.9	55.7
Study Skills	62.3	53.7
Science	55.7	63.1
Social Studies	70.5	56.4

The results for the year 1986-87 are listed in Table 2. A comparison of obtained results with anticipated results revealed weaknesses in language mechanics, in mathematics computation and, on the grade 6 test, in science. The results in language mechanics had been anticipated because the district's policy was to deemphasize punctuation skills. The CAT, on the other hand, devoted an entire section to language mechanics, including a heavy emphasis on punctuation and capitalization skills. A curriculum committee had been formed and recommendations were being made even as the initial results were received.

The results in mathematics were more troublesome. Scores in the computation subtest were lower than the anticipated score at every grade level. Yet the scores for concepts and application were higher than the anticipated scores at every grade level and seemed to run against the current trend in the country in which computational scores were rising at the expense of concepts and applications. A committee was formed to investigate the reasons for the low scores in computation.

Table 3

Comparison of Student Right Response On The CAT Subtest in Science National, Concord District and Beaver Meadow Elementary School* 1986-87

Science Subtest	Grade 4			Grade 6		
	N	CD	BMS	N	CD	BMS
Botany	63	72	57	59	60	56
Zoology	59	63	52	60	59	54
Ecology	57	61	49	71	76	75
Physics	64	72	68	69	78	69
Chemistry	55	62	52	59	69	61
Land, Sea, & Space	61	65	54	62	69	59
All Science	60	66	55	63	68	61

N= National
CD= Concord District
BMS= Beaver Meadow Elementary School
* At the time, Beaver Meadow Students attended Garrison School

In Science, the CAT items reflected content from physical, life and earth sciences. The specific subjects include botany, zoology, ecology, physics, chemistry and a category which the publisher of the test calls land, sea and space (Table 3). The test items measured understanding of scientific language, concepts, facts, and methods of inquiry in each content area. The percentages indicate the number of students who gave the right response in each major area of science compared to the percentage of students who gave the right response from the national norm group. Students in Concord's grade 4 achieved a consistent pattern of right responses over the national norm group in all major areas of science. Students in grade 4 at Beaver Meadow School established a pattern of right responses which was below that of their Concord classmates in every area of science tested. The pattern of right responses among Beaver Meadow students was below that of the national norm group in every area except Chemistry. Concord students in grade 6 achieved a right response consistently higher than the national norm group in all areas except botany and zoology which were at or near the national norm group. Beaver Meadow students in grade 6 achieved a pattern of right responses below that of their Concord classmates in every area tested. The pattern of right responses was within 4 percentage points of the national norm group on every test. In the botany, zoology, and land, sea and space subtests, the grade 6 Beaver Meadow students' scores were below that of the national norm. In the ecology and chemistry subtests, the percent of right responses were above that of the national norm group, and in the physics subtest, the percent of right responses were equal to the national norm group's.

Table 4

Comparison of Obtained Versus Anticipated Scores in Science on the CAT
At Beaver Meadow School* Grades 4 and 6
1985-86 and 1986-87

Grade/Year	Obtained	Anticipated
Fourth/1985-86	50	64
Sixth/ 1985-87	45	53
Fourth/ 1986-87	62	68
Sixth/ 1986-87	54	58

*- At the time of testing Beaver Meadow students attended Garrison

The results for Beaver Meadow, then called Garrison, were lower than anticipated in both grades tested for each year (Table 4). Since no tests were given in grade 5, the scores represent four separate student populations and indicate lower than anticipated scores for students in four grades over a two-year period of time. The weakness which was previously identified as a problem of students in grade 6 in Concord (Table 2), was evident among grade 6 students at Beaver Meadow (Table 4). The results for all of Concord's grade 4 students were above the anticipated scores (Table 3). The results for grade 4 at Beaver Meadow School, however, were lower than the anticipated results (Table 4).

In the fall of 1987, a pretest in science was administered to all students in Grades 4 through 6 at Beaver Meadow. The test was created by the writer with the assistance of the teachers in the intermediate grades, 4-6, at Beaver Meadow School. The test was adapted from end-of-chapter tests provided by the publisher of the textbook series which was introduced at the beginning of the 1987-88 school year (Appendix A: 91). Each of the chosen questions related to an objective in the curriculum which was written during the summer of 1987 (Appendix B:103). The test was designed to measure learnings in the

areas of Earth, Physical and Life Sciences during the intervention period of the practicum, September, 1987- June, 1988. The test was validated by the teachers in grades 4-6 and the principal at Beaver Meadow School by examining each question for its appropriateness for the age of the students and content being taught by the teachers.

Table 5
Comparison of Science Pretest Scores-Percent of Items Correct
Grades 4-6 At Beaver Meadow School
Fall 1987

Grade/Class	Area of Science Earth	Physical	Life	Total
Fourth	31%	28%	33%	30%
Fifth	46%	40%	37%	42%
Sixth	35%	42%	47%	41%

The results of the science pretest for Beaver Meadow students in grades 4 through 6 are listed in Table 5. The results were obtained by dividing the number of correct responses by the total possible number of correct responses in each of the three areas of the science curriculum: earth; physical; and life science. As the tabulated data indicate, the percent of items correct ranged from a low of 28 percent on the fourth grade questions relating to physical science objectives to a high of 47 percent on the sixth grade questions relating to life science objectives. The percent of items answered correctly by grade level ranged from a low of 30 percent in the fourth grade to 42 percent and 41 percent in the fifth and sixth grades respectively. Within the subtests of each individual grade the range of items answered correctly ranged from 28 percent in physical science in fourth grade to 33 percent in life science. In fifth grade percent of items answered correctly ranged from 37 percent in life science to 46 percent in earth science. In sixth grade, the percent of items answered

correctly ranged from 35 percent in earth science to 47 percent in life science.

Table 6
Comparison of Science Pretest Scores-Percent of Items Correct
Grades 4 and 5-Concord Elementary Schools- Fall 1987

School	Grade 4	Grade 5
Beaver Meadow	30	42
Broken Ground	35	40
Conant	36	40
Kimball	43	41
Rumford	29	30
Walker	39	50

The results on the pretest in science in the six elementary schools are listed in Table 6. As the tabulated data indicate, the scores ranged from a mean of 29 percent at Rumford School to 43 percent at Kimball. In grade 5 the mean scores were higher in general and ranged from a mean of 30 percent at Rumford to 50 percent at Walker. On the recommendation of the principals of the schools listed in Table 6, due to the sensitivity of the contract negotiations between the board of education and the teachers, a topic which will be discussed later, no test was administered to grade 6. For the same reasons, the data was not divided into categories of earth, physical and life science for the other five elementary schools as was done in Table 5.

Three surveys of the elementary science curriculum were conducted in the Concord School District. In 1983, a survey conducted by the curriculum coordinator for science was completed by all elementary teachers in Concord. The results indicated that, at best, 50 percent of the stated curriculum objectives were being met. Fourth and fifth grade teachers indicated that less than 20 percent of the stated objectives were being met. They also indicated that they taught many objectives which were not required and which the

curriculum listed at other grade levels. The survey also indicated that teachers believed the facilities and equipment available for the teaching of science were less than adequate.

Some of the results were more positive. Despite the teachers perceived lack of time and materials, the hands-on approach was the preferred method used to teach science and a vast majority of the teachers were making frequent use of two District owned and staffed facilities, the Science Center and White's Farm. Both were used as inservice center and classroom or outdoor laboratories for Concord students. (Birch, 1983).

In 1986, all seven of the elementary principals completed a "Principal's Checklist" (Mechling, 1983) on science, also distributed by the science curriculum coordinator (Appendix C: 137). In the survey, principals asserted that the science curriculum lacked a solid base, that teachers did not receive enough inservice training, and that material support for the curriculum was at best inconsistent.

In another survey completed in 1986, 61 percent of the elementary teachers claimed that there was not enough time to meet the curriculum needs. At the same time, those teachers listed the need for more time to do science as their top priority (Philippe, 1986). The teachers seemed to want to be a part of an excellent science program and wanted to be given the tools to do the job. A broader-based survey of science teaching in New Hampshire clearly showed that science at the elementary level was not considered important enough to be treated as one of the basic subjects (New Hampshire, 1983).

A survey of the Beaver Meadow School teachers in grades 4-6 which was conducted in the fall of 1987, revealed results similar to those identified in surveys previously discussed. Teachers were asked to identify the frequency with which they used various materials or techniques. The results were

averaged for the grade level and divided into weekly portions. For instance, the use of measuring instruments occurred approximately once a month at each grade level. When that figure was transformed into the number of times it was used in a week, the calculated figure was .25. The figures for the amount of time spent on science was taken from a weekly course of study form which is submitted at the beginning of each year. In October 1987, the figures which the teachers had recorded for the 1986-87 school year were returned to each teacher. The principal asked the teachers to review and revise the forms reflecting what had actually occurred. Where indicated by the teacher, the figures were adjusted to reflect the teachers corrected version.

Table 7

Results of Teacher Survey at Beaver Meadow School
Instructional Time, Percent of Objectives Met,
Use of Materials in Science-Grades 4-6
1986-87 School Year

	Grade 4	5	6
Time/Week (Minutes)	100	80	75
	Objectives Completed %		
Life Science	66	100	45
Earth Science	40	80	65
Physical Science	45	65	20
	Use Of Materials/ Techniques (Times/Week)		
Manipulatives (Kits)	0	0	0
Measuring Instruments	.25	.25	.25
Observer Logs	0	0	0
A.V. Material	.1	.1	.1
Textbooks	.2	.2	.2
Formal Verbalization	.1	0	0

The tabulated results of the teacher survey which was intended to identify instructional processes are indicated in Table 7. As the results indicate, during the 1986-87 school year, far less time was spent on science instruction than the

150 minutes a week which the New Hampshire State Department of Education Guidelines recommend. Science objectives were not covered in a consistent manner, and especially in physical science, some objectives were not covered by the teachers at all. In addition, materials and apparatus necessary for demonstration and experimentations were not used. Clearly, the lack of use of material, presentation of objectives in the curriculum and time spent on the subject affected student learnings.

What Has Been Done?

The last revision of the Concord School District Curriculum in Science was in 1978. During the first three years of implementation, a substantial quantity of materials were purchased and stored in the individual school libraries or in the Science Center. Purchased materials required that resource materials be shared among either several teachers in a school or among all the teachers in the grade. After-school, grade-level meetings were conducted to help teachers implement the new curriculum.

In addition, a Science Center was created. Staffed by an environmental science teacher, the center was a resource center for materials and was the site of inservice sessions for teachers. The staff of two teachers created a variety of environmental science and nature units and taught lessons on hawk watching, beavers, apples, cytology, snow shoeing and tracking. Nature walks occurred in all seasons and the program quickly became identified as the best part of the science curriculum. Unfortunately, for some teachers, it became the only science offerings in their classroom.

A few years later, the White Farm was donated to the school district. In it, the district not only acquired a working farm, a house and several acres of land, the land also created access to nearly two hundred acres of undeveloped

prime agricultural land and the Turkey River which flowed through it. When the program was expanded, the farm house became the residence of one of the science center staff. Teachers and students were not only encouraged to use the land to grow their own vegetables at the farm, but students were taught to raise and care for animals. The area also became an outdoor laboratory for many of the science units. Teachers who had previously worked with the science center staff were enthusiastic about the new area. For those teachers who had not worked with the science center staff, it was seen as more of the same rather than something to inspire them to teach more science.

In the summer of 1984, a group of teachers created behavioral objectives for the science curriculum. Initially, this was seen as a very positive improvement by the principals, but little attention was paid to the curriculum because other curriculum committees were introducing or implementing new ideas and techniques. Health, social studies and language arts committees were all at work improving or creating new curricula. The new science objectives were introduced without any teacher inservice or training. No additional funding was requested or provided. In fact, science became the only subject for which there was no line item in the individual school's budget.

Although the revision of other curricula shifted the teacher's attention away from science, the problems continued. One school abandoned the existing science curriculum and instituted a science kit program which they had used before. Principals complained about the lack of physical science and the lack of attention to scientific process. New teachers stated that the curriculum was incomprehensible. Training for new teachers was sporadic and limited mainly to what the teacher could learn from other teachers, the school principal, or the environmental science teacher. Several principals observed that their best teachers enjoyed the curriculum because it gave them a good deal of freedom.

But they also commented that the average, below average and new teacher felt lost. For the latter group, they further stated that the teachers' reaction was either to teach whatever science topics they wished, in effect ignoring the curriculum, or to rely entirely on the environmental science teacher to teach science.

Recognizing the problem, in the spring of 1986, the Assistant Superintendent of Schools appointed the writer as chairman of the Science Curriculum Committee. One teacher was chosen from each elementary school and a teacher and the chair of the science department at the high school and junior high school represented the secondary schools. The Assistant Superintendent charged the writer and the committee with the task of reviewing the science curriculum. The committee's first task was to write a philosophy. In order to accomplish the task the committee reviewed the current research, literature, and practices around the country. Once the review was completed, the committee hired writers and researchers to present workshops to the committee. Brinckerhoff (1986), Lansdown (1971), and Tokieda (1987) among others presented their research and experiences to the committee. After the series of readings, discussions and workshops, a philosophy and list of broad goals in science were written. Based on the goals and philosophy, exemplary practices in other districts were reviewed and textbooks from the major publishers were examined. After several months, the committee selected the Holt Science textbook and piloted it in several classrooms during the spring of 1987. Based on the positive comments of the teachers, the District purchased the series for implementation during the the 1987-88 school year.

Although supported by every member of the committee, several of the individual members of the committee expressed concern that the purchase of a new textbook, by itself, was not enough to address the problems expressed by

the teachers and principals. As the work of the committee came to a close and the school year ended, there was a feeling that if additional work was not done, all the learnings would be lost and the problems which the committee was trying to address would not be satisfactorily answered. A final communique from a committee member to the writer was a review from Science and Children which reviewed nine major newly published elementary textbook series, including Holt. The article found all of the textbooks gave little attention "to applying science concepts to daily life, to discussing the important science-related societal problems and issues, or to information on science careers." (Elliott et al, 1987:9-10).

Probable Cause

Several factors were listed as possible causes of the low achievement in science in grades 4, 5 and 6. Teachers in those grades reported increasing frustration with the curriculum. Materials were seen to be inappropriate for meeting the curriculum objectives (Philippe, 1986, Birch, 1983). Only a portion of the objectives in the science curriculum were taught (Table 7, Birch, 1983). Science material was inconsistently covered (Birch, 1983). There was an insufficient amount of time spent on science (Table 7; Philippe, 1986; Birch, 1983). In addition, principals complained that teachers lacked the necessary inservice support to adequately teach the science curriculum (Appendix C: 137).

Broader causes of low student achievement were also evident. Hurd suggested that student's lack of practice with real scientific problems and experiments was a factor. He cited historical evidence that educators have known for at least sixty years. Students like to learn science through the use of a hands-on approach and through experience-based learnings (1986). But it is also increasingly evident that instruction which relies exclusively on verbal

abstractions found in textbooks and lectures is contrary to current research about how children learn most effectively for it is beyond the reasoning ability of many children (Kyle, 1985). Many students, even into their late teens, need hands-on or at least a variety of experiences to intellectually understand and internalize a concept (Bruner, 1983). Perhaps this was why both the 1977 and the 1982 National Assessment of Educational Progress showed children to be less enthusiastic about science as they grow older (Pennick, 1986). These studies suggested that they were less successful in science courses than in other courses not because they could not do science but because of the way it was taught. Teachers in Concord seemed to recognize this fact and desired the materials and training to improve science teaching (Philippe, 1986).

Chapter 3

TERMINAL OBJECTIVES

The terminal Objective for this practicum was:

Terminal Objective 1- Student Achievement

As a result of improved methods of instruction, increased use of instructional materials, and increased amount of time spent teaching science during the period of October, 1987, to June, 1988, the average score achieved for each grade-level at Beaver Meadow School would improve the number of items answered correctly on a pre-test in science adapted from existing published materials to a level indicated below:

	Earth		Physical		Life		Total	
Grade	Pretest	Goal	Pre	Goal	Pre	Goal	+	
Fourth	31%	61%	28%	58%	33%	63%	30%	60%
Fifth	46%	76%	40%	70%	39%	60%	42%	72%
Sixth	35%	65%	42%	72%	47%	77%	41%	71%

The target goals were selected based on discussions by the Beaver Meadow principal with teachers in grades 4-6 at Beaver Meadow School, the science committee, the Science Center staff, and educational consultants from the textbook publisher. Each group reported that the test questions and subject matter were more difficult than required by the previous curriculum. It would, therefore be difficult they concluded, to obtain mastery, or an average score of 80 percent as defined by Concord School District, in each area. Based on the discussions, the Beaver Meadow School teachers determined that a reasonable goal for achievement in the first year of implementation would be an improvement of 30 percentage points from pre-test to post-test for each grade tested. The resulting target goal for fourth grade average score was 60

passing as defined by the Concord School District. Target goals of 72 percent and 71 percent were set for the average scores of the fifth and sixth grades respectively.

The process objectives for this practicum were:

Process Objective 1- Instruction/ Time Teaching Science

As a result of intervention by the principal, teachers in grades 4-6 will increase the amount of time spent each week on science, to a level consistent with the State of New Hampshire's guidelines for science instruction. Results would be recorded weekly by individual teachers and verified by the principal. Improvements in the amount of time are indicated below:

Grade	Time/Week/Teacher 86-87	Goal Time/Week 87-88
Fourth	100 minutes	150 minutes
Fifth	80 minutes	150 minutes
Sixth	75 minutes	150 minutes

Process Objective 2- Teacher Training/ Curriculum Completion

As a result of inservice training, the percent of objectives taught by teachers in grades 4-6 will improve as indicated below:

	% Objectives Completed 1986-87			1987-88 (Goal)		
Grade	Life	Earth	Physical	Life	Earth	Physical
Fourth	66	100	45	90	100	80
Fifth	40	80	65	80	100	90
Sixth	100	80	20	100	100	70

It was realistic to expect a high percent of the curriculum objectives to be taught because each teacher was expected to teach three required units, one each in life, earth and physical science, and one additional unit of choice. It was expected that the teachers would complete the required units first. The

teachers had reviewed the curriculum and had indicated that the goal of completing four units was realistic.

Process Objective 3- Instruction/ Use of Materials

As a result of an increase in the amount of instructional material in science and after training in the appropriate use of the materials, teachers would increase classroom use of the following materials as indicated below:

	Classroom Use of Material- Number of Times/Month					
	Grade 4		Grade 5		Grade 6	
Material	86-87	87-88	86-87	87-88	86-87	87-88
Kits of Manipulatives	0	5	0	5	0	5
Measuring instruments	1	5	1	5	1	5
Observer Logs	0	2	0	2	0	2
Audio-Visual Material	*	3	*	3	*	3
Textbooks	*	5	*	5	*	5
Formal Verbalization	*	3	0	3	0	3

*= less than once

The use of kits and textbooks would increase because the curriculum specified their use. The use of measuring instruments and audio-visual material would increase due to the acquisition in the fall of 1987 of many new scales, graduated cylinders and beakers, and other measuring devices as well as one overhead projector, tape recorder, and additional computer per grade level. Training in the use of these materials was a focus in the fall. Use of observer logs and formal verbalization was the focus of training in the winter and spring of the 1987-88 school year.

Chapter 4

DECISION ON STRATEGY

Research Findings

An understanding of how to teach elementary science was the focus of much of the research in science education. A primary finding was the emphasis on a "hands-on" approach to the teaching of science to elementary students. Kohlerman of the National Science Foundation declared that

> Hands-on science is the stepping-stone for getting kids to learn how things work and don't work. It is the critical link in preparing kids for the scientific and technological world they will face in the years to come (Cramer, 1987: 7).

The National Assessment of Educational Progress (NAEP) conducted a pilot study which demonstrated positive growth in students ability to think critically when hands-on programs were used. (Ashworth, 1987). Secretary of Education, William Bennett as cited by Cramer (1987: 9) maintained that

> Seen only as a laundry list of theorems in a workbook, science can be a bore, but as a 'hands-on' adventure guided by a knowledgeable teacher, it can sweep children up in the excitement of discovery.

Cramer also cited the National Science Teachers Association's list of "characteristics of a sound elementary science program" (1987: 9-11).

-a good program is logical and sequential
-the program is driven by objectives
-the curriculum should spell out broad ways for teachers to meet the objectives
-the district must commit sufficient time to science- 20-30 minutes a day or 40-60 minutes every three days
-hands-on curricula are best supported by the structure of a published textbook program or kits
-inservice training is essential
-curriculum goals and materials must match
-textbooks and kits must include tests and other evaluation materials

-there should be a balance between life, earth and physical sciences
-content and process should help kids learn about the world around them, the increasingly technological world and the difficult decision they face
-science should help children to apply what they learn to the real world

Earlier research in mathematics reported similar findings. Driscoll found that since children up until the age of seven or eight cannot usually handle more than one variable at a time, asking a student to work without the use of concrete objects "may well be asking for the impossible." (Driscoll, 1980:12) Citing the work of Bruner and Dienes, as well as the developmental theories of Piaget, Driscoll concluded that:

> manipulatives not only show the way to conceptual understanding, but they provide experiences in which children can transfer their understanding smoothly from one concept to another. By their appeal to a variety of senses, they also motivate children. (Driscoll, 1980:27)

The one caution he offered was that "the quality of learning is not inevitable and that children cannot learn mathematics well with manipulatives alone." (Driscoll, 1980:27)

One of the methodologies found to be most effective was the use of verbalization. Tokieda reported successes among students in kindergarten through high school in the acquisition of scientific knowledge through the use of scientific techniques of investigation using hands on materials and verbalization which he called the "colloquium" (1987). Included during the 15 years using the Investigation-Colloquium Method (ICM), were significant successes with learning disabled, gifted, and private school students. The psychological foundation for the colloquium was based on the work of Vygotsky (1962) who formulated the idea that concept development stemmed "from the dynamic interaction between thought and language- that language helps develop thoughts and thoughts help develop language." (1987:3). Tokieda asserted that, "it is the 'thinking out loud,' that enables one to crystallize an idea and to internalize it intellectually

as a 'personal' concept." (1987: 3). He stated that Lansdown developed the ICM "based on the fact that children (and adults) learn best by doing and discovering and then by talking about their discoveries." (1987: 1) What was especially significant according to Lansdown was that during the investigation, children explored with materials "which the teacher has carefully structured around predetermined concepts," or structured self-discovery (1987:1). The teacher's role in the colloquium was vital but discreet focusing on pointing out discrepancies in student observations, redirecting group attention to contradictory statements, providing vocabulary for terms which students cannot discover, and avoiding judgmental statements in reaction to a student's observation.

The finding that verbalization was an important component in learning was identified in studies of learning in the area of mathematics as well. In a study to "develop children's interest in achievement through verbalization," students were specifically taught to use descriptors to explain and reinforce the strategies used as part of the algorithms which they were taught (Schunk, 1981). When students were specifically taught operational strategies and allowed and encouraged to use their own words in verbalizing the strategies, they had greater skill development, stronger feelings of efficacy and more interest in mathematics than either students who verbalized without instruction in the strategy or those who were instructed in the strategy but could not freely verbalize (Schunk, 1981).

In the areas of reading and writing, researchers also found that verbalizing was an important component of learning and retaining concepts. Speaking on the topic of preparing students to read and write fiction, Paratore stated "It is important that children have a procedure that they can articulate so it becomes routine." (1988) Paratore reported that verbalizing routines and strategies "to

prepare the students mind for learning" increased the child's learning of information in reading and resulted in a better written work product.

The Far West Lab Study of 1975 supported the finding that verbalization combined with the use of manipulatives was an effective method of instruction. Suydam's work on the use of concrete materials also underscored the role of verbalization in the finding that:

> language is learned informally as children communicate about what they are doing and what they see happening. As they use models, they should begin to understand the symbolism related to the operation.(1978:16).

Research on the role of the principal linked student achievement and the degree to which the principal was seen as the curriculum leader of the school (Hersch 1982). Similarly Biester (1983) showed improvement in student achievement when the principal had direct knowledge of the program through training and experience, conferred regularly with teachers about the program, and monitored the progress of the program.

A large body of literature on the topic of science teaching was dedicated to a discussion of issues involving science, technology and society (STS). The National Science Teachers Association dedicated its 1985 Yearbook to the topic and recommended that 20 percent of all instruction in science involve STS issues (NSTA, 1985). The popularity of the issue among the science teachers resulted in 1986 of a series of annual conferences in Washington D.C., in 1983 the Exeter I Conference, and in 1985 the Exeter II Conference and in the publication of journals including the Bulletin of Science, Technology and Society and STS Reporter. While agreeing with the hands-on approach, use of manipulative materials and the scientific method for the instruction of science, the proponents of STS question whether the goals are sufficiently broad to meet the need of the future generation. Brinckerhoff and Yager (1985) called for

science curricula to be designed to make our children scientifically and technologically literate, to think critically and to understand the consequences of technology. Along with imparting knowledge of the process, major concepts, principals, laws and theories of science, a good science program should also include teaching students to differentiate between conclusions drawn from scientific evidence as opposed to unsubstantiated opinion, to expect and deal with technological change, to recognize that the future of humankind and the quality of life are not matters of fate, and to use their knowledge of science to make decisions that will lead to a more desirable world (Kyle, 1985). Not doing so results in the notion that scientific findings are absolutes, or in what Shipman calls "a widespread inability to handle shades of gray" among college level graduate and undergraduate students which denies future generations "the tools to evaluate and think through issues for themselves." (1986: 24)

Researchers had examined achievement in science in light of teaching methodologies, materials used for instruction, theories of child development, and content and structure of the curriculum. A review of the literature had also explored the importance of the teacher, and the principal and the ways in which children like to learn science. All these variables may have influenced performance in science.

Analysis of Problem Setting

The Concord School District was ready to change the way science instruction occurs in the classroom. In the spring of 1986, the Concord Board of Education made a decision to revise the science curricula in grades K-10 and allocated monies from local, state and federal sources to purchase materials which supported the revised curricula. For several years, teachers had registered their dissatisfaction with the science curriculum content, materials,

and to some degree, the methods. Principals had declared the curriculum to be inadequate and the students in the intermediate grades had not performed to expectations of the standardized achievement tests in science. At Beaver Meadow School, teachers had indicated dismay at the science curriculum's lack of focus and balance. Those same teachers had also indicated a willingness to try new ideas and to pilot new programs. Such support and interest were positive indicators for the success of any intervention strategy.

During the summer of 1987, new curriculum objectives were written by the science committee and a new textbook series was ordered. The program of instruction was Holt Science, for grades K-8 (1986). It emphasized hands-on experimentation and contained kits which correlated to the textbook and curriculum objectives. The textbooks and kits were supplemented by the purchase of scientific apparatus for demonstrations and experiments. This infusion of new instructional materials created a demand for inservice activities involving the demonstration of instructional methodologies.

The district had two additional resources which have been seen by many teachers as the best of what occurs in science in the district. The Science Center and the White Farm existed and were staffed by district personnel. Both offered excellent opportunities for an experiential, hands-on approach to nature study and classroom support. Both staffs were interested in creating additional units to support the new curriculum and to provide teacher support and training.

Several factors existed which may have hindered the implementation of any new programs, however. The problem which had the most negative potential was the fact that teachers in Concord were working without a contract. Contract negotiations continued but job actions were increasing and there was talk among the union representatives of a strike. During the fall of 1987, the

union had asked that all staff members resign from committee work. All members of the science curriculum committee had resigned. The union had also asked that no staff attend inservice activities which occurred outside of the regular school day. Since the school calendar allowed for only one inservice day, one which coincided with the state teacher's convention scheduled in October of 1987, there were no days in the year when all the teachers could have attended an inservice activity.

The choice of promising strategies had to take into consideration the needs of the school and the strategy's impact on improving achievement at Beaver Meadow School. Raising moral issues and the clarification of values which were the focus of much of the STS materials and literature resulted in increased student interest in science (Brinckerhoff and Yager, 1987). Student interest in science had been positively correlated to achievement in learning scientific processes and content (Pennick, 1985). Yet most of the STS materials available were appropriate for secondary, not elementary school students. Also, within the Concord District, elementary school programs at the White Farm and Science Center included STS issues on a regular basis. While student and teacher interest in these programs was high, achievement scores in the intermediate grades continued to be low.

Additional factors were present at Beaver Meadow School which may have hindered the success of any intervention strategy. For instance, teachers had additional pressures placed on them due to increased student population and dislocations due to the completion of an eight-classroom addition. Increased population at the fifth and sixth grade levels could have necessitated the hiring of additional staff which would have resulted in a restructuring of classrooms and additional change. Any strategy chosen would have been affected by the degree to which any of the identified variables predominate.

Promising Strategies

Strategies for improving achievement in science, which appeared most prominently in the research, included the introduction of a balanced, sequential curriculum, the use of hands-on materials backed by kits and/or textbook for instruction, the time spent on instruction, the methodology of instruction, teacher training and inservice, direct involvement of the principal, and the focus on societal issues.

The focus on teacher training in methods of instruction merited consideration. The decision to use hands-on materials had already been made. A new textbook series which emphasized student experimentation was supplemented by kits which were correlated to the textbook and the curriculum objectives. Any inservice program for teachers would necessarily have had to include the use of manipulatives and the new instructional materials.

If the teacher's contract negotiations had not been resolved during the early stages of the practicum implementation, training and inservice sessions would have been more difficult to arrange. If teachers continued to work, substitutes would have had to have been hired to assume classroom duties while the seven teachers at Beaver Meadow School attended inservice sessions. If a strike occurred, inservice sessions would have been postponed and an extension of the practicum implementation would have been necessary. Given the strike-free history of negotiations between the teachers and the Board of Education in Concord, the contingency plan discussed above was a remote necessity.

The inclusion of verbalization as a means of improving the learning and retention concepts had potential for success. During the 1986-87 school year, based on research findings cited earlier, several Beaver Meadow School teachers

encouraged their students to verbalize strategies for solving computational problems in mathematics as a part of a program to improve achievement (Schunk, 1981, Driscoll, 1980). Many of the teachers attended courses in "Math A Way of Thinking" where they learned the importance of using manipulative materials in mathematics instruction. With such a basis and with the available supporting research and materials, a similar program in science seemed promising as well as practical. It was anticipated that such a program would be readily accepted by the teachers and students, and it was supported in the literature (Schunk, 1981, Driscoll, 1980, Suydam, 1978). Through the ICM, it demonstrated effectiveness in science learning (Tokieda 1987, Lansdown, 1971).

Selected Strategy

The strategy most likely to achieve success was to improve instruction by increasing the amount of time spent teaching science, training teachers to teach the new curriculum and to use new materials appropriately, and insuring that the required curriculum was taught. In order to achieve this, the principal played an instrumental role. His focus was to provide overall leadership to the project, and to acquire the materials and training necessary to instruct teachers in the correct techniques for using manipulatives and verbalization of concepts to improve achievement and understanding in science.

Teachers were trained to use the new textbooks and curriculum. As part of their learning and to increase the probability of success, the teachers studied, discussed and recommended possible changes in the required and optional lessons as directed in the curriculum. Teachers prepared lessons to teach to their students. The teachers then became familiar with the research on use of hands-on materials and verbalization in science.

As discussed in Chapter Two, the teacher survey distributed prior to

intervention, showed that none of the staff in the target classes used manipulatives or observer logs in their classrooms. Yet the research indicated that students' achievement in science and math has improved through the use of such materials (Tokieda, 1987, Driscoll, 1981, Suydam, 1978, Lansdown, 1971). The teacher survey also indicated little use of verbalization as a formal part of the instructional program in science. The research indicated however, that verbalization should be included (Tokieda, 1987, Schunk, 1981, Lansdown, 1971, Vygotsky, 1962). Training in the use of such techniques and materials was a part of the selected strategy.

After being trained in the use of manipulatives, verbalization, observer logs and appropriate apparatus to implement the new curriculum, teachers developed lessons. When lessons were developed, Beaver Meadow teachers taught the lessons to their students. After several lessons had been developed, the teachers presented lessons in a workshop for other teachers in the district. Working with the science curriculum committee, Beaver Meadow School teachers of grades 4-6 who had volunteered and who had been observed and judged to be proficient in the ICM by the principal led grade-level workshops in which they shared their ideas and experiences and demonstrated a lesson.

Chapter 5

IMPLEMENTATION

Prior Activities To Practicum Implementation

As described in Chapter 2 (p. 19), several practicum activities occurred prior to implementation. These activities included formation of a science committee, articulation of science goals and philosophy, and selection of materials and strategies to implement the goals and philosophy. The science committee and the writer, as chairman of the committee, were responsible for recommending the materials and strategies eventually adopted by the district and implemented during this practicum.

The science committee began meeting in April, 1986. On April 8, the assistant superintendent for curriculum met with the committee, introduced the principal of Beaver Meadow School as chairman and outlined the tasks to be accomplished. He asked the committee to write a science philosophy and goals statement, to define the scope and sequence of science education from kindergarten to grade 10, to review the literature, to identify good practices in other districts and, based on the results of the investigation, to recommend materials and strategies needed to implement the philosophy and scope and sequence. The committee members work assignments were made and the meeting dates were selected. The committee chairman asked all members of the committee to forward to him any findings among the research and literature on science so that material could be reproduced and shared with the subcommittee responsible for the initial draft of the philosophy. After surveying the literature, the subcommittee would circulate recommended articles among the full committee.

In May of 1986, the subcommittee responsible for writing the philosophy met to discuss the research and literature. After discussing the literature, the committee assigned individual members the task of contacting writers and researchers who best represented the current thinking and practices in science. The committee identified two trends previously discussed in Chapter 4. The first was a return to a hands-on approach in science instruction, especially at the elementary level. The second trend was introduction of societal issues into the discussion of science, especially at the secondary level.

As a result of the committee's search, Lansdown (1971), Brinckerhoff (1985) and several others were selected to address the committee. Lansdown had been identified by one member of the science committee from an article in the Christian Science Monitor (Eddy, 1986). The piece described the work of Lansdown and her approach to science education. After determining that her approach was consistent with the methods and approach identified by the committee as appropriate for elementary science education, a committee member contacted her at her home in Cambridge, Massachusetts. Lansdown agreed to present her Investigation Colloquium Method (ICM) to the science committee. In a similar manner, Brinckerhoff, sponsor of the Exeter II Conference was invited to address the committee. Workshop dates were scheduled for both individuals to meet with the committee.

On May 27, 1986, Lansdown presented a workshop to the science committee. At Lansdown's request the number of participants was limited to 20, including the committee, the assistant superintendent for curriculum, the science center staff, and Concord School District's seven elementary principals. Using materials easily found in homes and schools, Lansdown led the participants through a lesson on magnetism. In the investigation portion of the lesson, participants used magnets to determine which objects responded. In the

colloquium, the participants met in a circle and came to agreement about the influence of magnetism on various materials.

All participants indicated that they were very impressed with the lesson. The verbal responses from all the principals and teachers to the chairman were positive. In an informal meeting after the workshop, all agreed that the ICM was worth pursuing as a strategy to improve science education in the Concord School District. Three committee members who had volunteered to drive Lansdown back to her home agreed to ask her to do another workshop. When the subject was raised later that evening, however, Lansdown declined. She stated that she had been asked to write and teach science and math curriculum at a teacher-training school in Peking, China and needed to spend much of her time in China. She recommended that one of her former graduate students at Harvard University, Tokeida, be approached to do the training. At a subsequent meeting, the science committee decided to continue the schedule of meetings and workshops before contracting with Tokieda to train teachers in the ICM.

On June 10, 1986, Brinckerhoff met with the science committee to discuss science, technology and society (STS) issues. Brinckerhoff, a former science teacher at Exeter Academy, presented the argument for including sciences affect on society as a part of the curriculum. After the meeting, the committee decided that the issue was most appropriate for inclusion at the secondary level and agreed to invite Brinckerhoff to present a workshop to the secondary science staff.

During the summer of 1986, two committee members wrote a draft of the science philosophy. The committee reviewed the document and presented the goal and philosophy in a final document to the Concord Board of Education for approval. Once approved, the committee continued to sponsor workshops and review materials and strategies which would be consistent with the philosophy

and goals. A textbook series which emphasized a hands-on approach was recommended for piloting (Holt Science, 1986). Kits with enough materials for all students in each class were recommended for purchase. Apparatus for measuring and experimenting was identified and two instructional strategies for implementing the curriculum were selected. For the secondary students and teachers, the committee recommended that STS issues be included. At the elementary level, the committee recommended the ICM.

On May 15 and 16, 1987, the committee hired Tokieda to lead a workshop using the ICM. The purpose of the workshop was to train teachers to become ICM trainers so they could lead workshops the following school year. In addition to the members of the science committee, the principal of Beaver Meadow School invited a fourth, a fifth and a sixth grade teacher from the school to attend. The workshop was held at Beaver Meadow School on a Friday afternoon and evening and all day the following Saturday.

During the workshop, Tokeida modeled the ICM technique through the investigation and colloquium stages. Teachers played student roles throughout the sessions, asking questions of pedagogy after each session had been completed. Teacher response was uniformly positive. Several teachers expressed satisfaction with the approach. One stated that she used a similar technique in all her teaching. Another expressed anxiety about having to face his peers in the fall, "I hope I'll be more comfortable with the ICM by then."

By noon on Saturday, May 16, 1987, all participants appeared to be weary. Tokieda modified the afternoon lessons on capacity and volume to shorten the duration of the workshop. When the workshop concluded at 3 pm, Tokieda presented the participants with copies of an essay about the workshop and philosophy. (1987)

At their next meeting on May 20, 1987, the science committee voted to

include a section on the ICM from Tokieda's article in the philosophy and goals statement. It reaffirmed the decision to recommend the ICM as the preferred technique for teaching science at the elementary level. The committee agreed that teachers who were trained in the ICM should be paid during the 1987-1988 school year to present workshops to other teachers who taught the same grade. In addition, the committee recommended the purchase of teacher's guides to the new textbooks for teachers use during the summer of 1987, and also recommended the purchase of kits and apparatus to support the textbook, and observer logs and measuring tools to support the ICM. All of the recommendations were adopted and materials were ordered.

By the time the school year ended in June 1987, it appeared to the principal of Beaver Meadow School, that all essential elements were in place for a successful implementation of the new science curriculum. It seemed to him that there was only one issue which could adversely affect the implementation: the unresolved negotiations between the teacher's association and the Concord Board of Education.

Contract Dispute

In the fall of 1986, contract negotiations between the Concord Board of Education and the representatives of the teacher's bargaining unit, the Concord Education Association (CEA) began. During the 1986-1987 school year, many negotiating sessions occurred but no agreement was reached. During the summer of 1987, a fact-finder was hired by the school district and the CEA. The fact-finders report was to be released during the second week of the 1987-1988 school year. As a result, at the beginning of the school year, there was no agreement on a master contract.

The lack of a negotiated master contract between the Board of Education

and the CEA presented the Beaver Meadow School principal with a problem. Teacher cooperation was essential for the success of this practicum. Lack of enthusiasm about the practicum intervention components would adversely affect the results of the intervention. If for some reason, the teachers refused to cooperate, the practicum would not be possible. The Beaver Meadow principal had to devise a strategy to begin the practicum during negotiations without alienating any of the parties involved in the contract dispute. At the same time, alternative strategies had to be developed in the event that the contract negotiations continued throughout the entire year.

The principal decided to prepare teachers for the interventions in science while remaining sensitive to the difficulties such interventions may pose for individual teachers. As a result of this decision, the principal informed the Beaver Meadow staff at the first staff meeting of the year on September 1, 1987, of the effort to improve science education. He asked for their support and asked staff members interested in training other teachers in the recommended techniques to be used with the new curriculum to see him within the next two weeks. Since any teacher who openly volunteered for extra work risked alienation from other teachers, the principal did not ask for volunteers to identify themselves at the meeting. The staff was therefore, informed of the practicum but was not placed in the uncomfortable position of choosing between the wishes of their union or their principal.

A few days later in September, teachers were directed by the CEA to resign from all committees. All the members of the science curriculum committee resigned. This action presented the principal with another problem. As described in the previous section, the science committee was responsible for selecting the textbook and support materials. Committee members had attended the April 1987 workshop and committee meetings at which decisions were made

regarding the science curriculum. The committee was responsible for writing the goals and philosophy adopted by the district and from which the strategies for implementing the curriculum were selected. In addition, the committee members participated in discussions with the writers and researchers on which this practicum intervention is based. Without the support of the committee and with limited support from the Beaver Meadow staff due to constraints from the union, the principal faced a dilemma. The principal had three options: he could present the workshops himself; he could postpone the workshops until negotiations were resolved; or, he could find non-union staff to present the workshops.

Role of the Science Center Staff

As an interim solution to the contract and timing issues, the Beaver Meadow principal asked the science center staff for assistance in implementing the curriculum. The two science center staff were members of the science committee, and had attended the inservice training session with George Tokieda at which the ICM was discussed and modeled. Since every elementary student and teacher in the district visited the center at least twice a year, the opportunity existed to demonstrate teaching strategies. In addition, the science center staff were not part of the teachers' bargaining unit, allowing them more freedom of activity.

The Beaver Meadow principal asked the science center teachers to conduct their lessons using the ICM. If the science center teachers agreed, classroom teachers who were new to the method could observe it. Any teacher who had some experience with the ICM could learn more about it. It also avoided the union's admonition that teachers not participate in inservice activities after their regular school day. The two teachers from the science center agreed and

began ICM lessons at the science center in October 1987.

In November 1987, the science center staff again provided assistance. Before the contract settlement between the teachers and the Board of Education was reached, the Beaver Meadow principal sought a way to distribute and introduce the new science apparatus to teachers. All science committee members who were originally supposed to provide the assistance had resigned. Someone else had to assume their duties. Although the CEA had directed its members not to attend inservice activities, they continued to support attendance at regular staff meetings, therefore providing another opportunity to communicate with the teachers. When the Beaver Meadow principal asked one of the science center staff to help by presenting the materials to the Beaver Meadow teachers, the staff member agreed.

On November 12, the science center staff person met with Beaver Meadow teachers. She distributed the scales, thermometers, greenhouses, weights and other measures, one to each pair of teachers. "You're job is to list all the things you could do in science with this," she said. After five minutes she asked each pair of teachers to read their list to the rest of the staff. When all of the teachers had reported their lists, the science center staff distributed a sheet of paper which had been prepared earlier by the principal and science center staff. On the paper was listed the item's scientific name, and the chapter in the textbook and grade level where the apparatus should be used. The teachers appeared to be interested and excited about the new materials, especially when the materials list was distributed. A fourth grade teacher stated that her class had not done well on the first chapter in the textbook, but thought that the new materials might make a difference. She stated that she planned to return to the chapter later in the year and see how well the students learned using the new materials.

After the meeting, the principal discussed the positive reaction of the teachers to the science center staff's presentation. He asked the staff member to present the same workshop to teachers in the eight other elementary schools. The staff member agreed, and with the assistance of the other elementary principals who provided time during their staff meetings, the materials were distributed. According to the science center staff, the reactions were as positive at the other schools as they were at Beaver Meadow.

At the same meeting, the principal invited the science center staff person to help train other teacher trainers. By using the ICM on a daily basis, she had become very familiar with the technique, and in the opinion of her co-worker and the principal, used it very well. She seemed pleased to be asked and readily accepted the invitation. It was at this time that the principal reflected on the important contribution of the science center staff to the implementation of the practicum. Although the teachers at Beaver Meadow were supportive, they did not wish to act against their union. Had it not been for the science center staff, there would have been no sharing of the type originally planned.

The science center staff continued to play an important role throughout the practicum. For instance, the science center staff prepared and delivered to the schools curriculum kits. The kits were selected by the original science committee to provide students with hands-on experiences related to the lessons in the textbooks. As will be documented later in Chapter 6, the kits were used frequently and were well-liked by the teachers and students. When they arrived at Beaver Meadow School in late September 1987, the teachers had anticipated their arrival and began using them immediately. One fifth grade teacher expressed what appeared to be the typical reaction, "I love it! All of the kids (sic) are busy working with materials and everything is right there for you. You don't have to go scrounging around for it."

To insure that the kits would continue to be used, the Assistant Superintendent for Curriculum assigned the science center staff the task of replenishing the kits as they became depleted. He also recognized that the district would save money by gathering the materials itself rather than reordering everything from the company which made the kits. Between the Christmas and New Year holidays, the science center staff replaced all needed materials in the kits.

Role Of The Beaver Meadow School Teachers

If and when the contract negotiations were settled, the principal wanted the Beaver Meadow teachers to be ready to train other teachers in the district. With the help of the Assistant Superintendent for Curriculum, the principal obtained a grant to pay teachers $25.00 an hour for workshops presentations. With this in mind, during the first week in October 1987, he asked the Beaver Meadow School teachers who had attended the ICM workshop, to begin developing science lessons using the ICM. All four of the teachers agreed. Implicit in their selection to participate in the Tokieda workshop was the expectation that, at a later time, they would train other teachers. What was not anticipated was the degree to which the principal had to rely on these teachers.

With the contract dispute eliminating the science committee as a resource, the Beaver Meadow teachers' cooperation became more important to the success of the curriculum interventions. The four teachers who had been trained to use the ICM had been carefully selected by the principal, based on their availability and on their interest in assuming a leadership role during the practicum. During the previous year, two of the three fourth grade teachers had begun team teaching some units. Both were interested in science and the ICM. Because

the other teacher had not taught fourth grade since 1973, she had new techniques and materials to learn during the year. The fifth grade teacher who had agreed to be a trainer had presented several well-received science workshops in the district. The other fifth grade teacher was teaching a combination fifth and sixth grade classroom requiring additional planning during the year. In the sixth grade, the teacher who agreed to be a trainer was very enthusiastic about science, the new curriculum and the ICM. As chief negotiator for the teacher's union, the other sixth grade teacher had additional time commitments placed on him.

On October 13, 1987 the principal met with the four teachers to plan the training activities. The resulting plan involved the four Beaver Meadow teachers working initially on their own, to develop an ICM unit from a lesson in the textbook. Then, they would refine their efforts by working with each other. As a final step before they began training district staff, they would work with the other teachers at their grade level at Beaver Meadow School. Beaver Meadow teachers would therefore begin implementing the ICM before other schools in the district.

Contract Resolution

During the final two weeks in October 1987, the Board of Education and the Concord Education Association agreed to a contract. At the end of the month the contract was ratified by both parties. With this long awaited announcement, the Beaver Meadow principal made plans to begin the teacher training.

On November 3, the principal announced a schedule of science workshops to begin in December and continue to the end of January 1988. Coincidental to this announcement, the director of reading, and the computer coordinator

announced workshop schedules which involved the same teachers on many of the same days. All three had been waiting for the end of the contract negotiations and had readied schedules for the same time. After a meeting, the three agreed to have the reading workshops begin in December, the science in January and the computer in February.

After the principal became aware of the schedule conflict, he began developing options with the teachers who were to do the training. The principal proposed that the Beaver Meadow teachers work with some members of the science committee to present the workshops. In that way the previously scheduled workshop time in December could be used for the Beaver Meadow and science center staff to share their experiences with the science committee. It would also allow more time for lesson preparations, and for the schedule conflict to be resolved. All teachers seemed pleased by the inclusion of more teachers and by the extension of time. One of the fourth grade teachers said, "Oh, thank you. We've changed our lesson a dozen times and are still not satisfied with it."

Implementation By Beaver Meadow Teachers

Implementation began during the last week of September and the first week of October 1987, with the administration of a science pre-test to Beaver Meadow students in grades four through six. (Appendix A: 91) The test was adapted by the principal and Beaver Meadow teachers to measure curriculum goals in life, earth and physical sciences. Fourth grade students answered 30 percent of the questions correctly. Fifth and sixth grade students scored 42 percent and 41 percent respectively. One teacher complained to the principal that the test was discouraging for her students. "They did so poorly and felt so bad. I really felt sorry for them." Another fourth grade teacher who heard the

teacher said "Yes, and we have math tests and the CAT California Achievement Tests to give too. These poor kids are being tested to death." Reactions from the other teachers were more positive, but all agreed that there was too much testing at the beginning of the year.

With initial data gathered, the teachers began using the textbooks, materials, and for some, the ICM. In October, the fourth grade students studied life science. Animal and plant communities were studied and observer logs were introduced in a hawk migration unit. Each child used the observer log to record the number of migrating hawks observed during their rotating watch. At the end of their one or two hour watches, the group of four to five students returned to the classroom to report a summary of findings. The number and type of hawks seen were graphed daily. Whenever a kettle of migrating hawks was observed, the students would notify the other fourth graders so they could join in the watch. Since Beaver Meadow School was located in the northern part of the city, the students were usually the first to see large numbers of hawks migrating together, so they would relay their findings to other fourth grade classrooms in the district. The hawk watching unit presented the teachers with their first opportunity to use ICM. It was also an opportunity for the ICM to be shared with the other fourth grade teacher so she could begin using the technique. For the investigation stage of the ICM, the students predicted whether or not it would be a good day for observing hawks. They learned that hawk migration seemed to relate to weather conditions. If the wind blew in a northerly direction, few hawks were seen. If it blew in a southerly direction, more hawks were seen. If the wind had been blowing in a northerly direction for several days and suddenly changed to the south, large numbers were recorded. As one fourth grader stated, "They're not dumb, you know. It's easier to go with the wind than against it." The two fourth grade

teachers who had volunteered to lead training sessions met by themselves and with the principal on several occasions to plan their model lesson. They requested more time to prepare and stated that they were not at all comfortable with the task. With the contract dispute continuing, the principal was wondering whether any workshops would occur. It was easy therefore to assure the two that they had some time to prepare.

During the month, the fifth grade students studied physical science with units on electricity and magnetism. The ICM was used in both units. Students working in groups of three and four predicted which lights, buzzers, and bells would work based on their investigation of series and parallel circuits, and which magnets would attract what materials. The colloquiums which followed allowed the students a chance to report their findings, review their hypotheses, and make conclusions based on their accumulated data. The fifth grade teacher who had volunteered to teach the ICM to her peers said that her lessons had gone well and that she was prepared to lead them whenever the principal by team-teaching science with the other fifth grade teacher. In this way, the other teacher not only learned the ICM, but began to use the approach with the sixth graders in his class.

In October, the sixth graders studied earth science. The teachers combined the unit on the changing earth with a social studies unit on map reading and introduced the observer logs as writing assignments. Using land form models, the students tried to predict climates based on data from ocean currents. The teachers reported successes with the materials, and concepts taught. The teacher who had volunteered to do the training decided however, that this earth science lesson was not the one she wanted to use as a model. "I think I can come up with better hands-on lessons." she said, indicating some discomfort with the ICM.

At a staff meeting on November 12, the principal asked the teachers to report on a monthly basis, their successes, problems, use of materials, time spent on science, etc. on a survey form (Appendix D:139). The principal explained that the survey would be used to monitor and document progress, and to identify any problems which may not be addressed in staff meetings, individual discussions or in workshop sessions. There were no comments made about the survey, and the principal did not perceive either a positive or a negative response to it. He concluded that the teachers understood the need for the documentation and as a result did not resent the request to complete the surveys.

During the month of November, the fourth graders completed their life science units on plants. One teacher began a physical science unit on machines. She stated that she had modified the lesson on the inclined plane from the one presented in the book. Instead of lifting a box of books using an inclined plane, she had the students push a barrel. She said that the vocabulary in the book was presenting problems for the children. Since much of it was based on material normally introduced in earlier grades, having a new textbook required additional teaching. The concepts were difficult for the students to grasp. "I wonder if they'll remember any of this at the end of the year," she added.

The fifth grade students studied life sciences during November. One teacher announced to her class that they were going to become parents by adopting a living thing. For two weeks the students prepared for their responsibilities without knowing what their "adoption" was to be. It became the topic of writings, observer logs, and hypothesis formulations. Finally, the meal worms arrived and the students began experiments. Through the ICM, they determined whether the meal worms liked light, heat, cold, sweet, salt, or sour (vinegar and lemon). They recorded their observations in their logs and during

the colloquium. Charts and graphs were made reflecting the data gathered. The fifth grade teacher who taught the unit was sufficiently pleased with the lesson that she decided to use the meal worms lesson during her session of teacher training.

The sixth grade teachers completed their physical science unit on matter. As they did in October, they integrated the lessons with language arts and social studies. One teacher stated that the lessons fit nicely with existing audio-visual materials. "Before, we had to make up lessons around these film strips. Now they supplement the book." Two of the three sixth grade teachers were now using the ICM.

In November, none of the fourth grade teachers met the time guidelines of 150 minutes a week each week. Even considering the fact that Veterans Day, Thanksgiving, and teacher conference day all reduced the amount of time available in the week, only one teacher met the equivalent of the standard three out of four weeks, another teacher met the standard two out of four weeks, and one teacher taught the equivalent of 120 minutes each week. Even so the students appeared to be learning and enjoying science more than they had in previous years.

In contrast all the fifth and sixth grade teachers met or exceeded the guidelines every week. One sixth grade teacher approached the principal in private and said "I probably shouldn't be saying this to you, but I never taught science last year like I'm doing it now. It was always 'Well, if I have the time', or maybe a 30-minute lesson once a week. Now, the kids are always after me 'can we do science now?' It's even fun for me. The kits make it so easy and the activities are super!"

On December 2, all fourth, fifth and sixth grade teachers at Beaver Meadow School attended the first of four reading workshops (Paratore, 1988).

Although the topic was about preparing students to read and write different types of reading and writing, the teachers believed that many of the points related to the elements of this practicum. In discussions after this and subsequent workshops the teachers concluded that some elements were exactly the same. A sixth grade teacher stated "When we do word mapping with the students to get them to list all they know about a topic and to conjecture about what the story content is, it's just like the hypothesis before the investigation in ICM." A fourth grade teacher said, "Yes, and Paratore reinforced the colloquium when she said that you need to hear the kids verbalize to insure that they have understood the concept." That led the fifth grade teacher to say "It's just like what we are getting the kids to do in math; they need to verbalize the strategies for problem solving." The discussion continued with a conclusion that perhaps there was something called generic teaching which was reflected in all the research in each content area, but that no one had yet seen the connection.

Later in December, the staff member from the science center shared an article about meal worms with the staff. The article served to reinforce the practicum goals and current experiences.

> A second grade teacher brought mealworms to school so her students could observe metamorphosis at first hand. As she expected, youngsters eagerly watched the transformation from larva to pupae-but when the adult form emerged they were flabbergasted and asked her who had put a beetle in the jar. Once persuaded that mealworms were really turning into beetles, the children attributed the change to the mealworms' diet of potato bits and beetles' color to the color of the food they had eaten as larva. Straightening out these misconceptions required a series of experiments in which they kept mealworms in several containers and fed them different diets.
>
> As we do every day, these children constructed an intuitive explanation for a phenomenon they had observed. They were fortunate that their teacher encouraged them to talk about their theories and then arranged experiences that would help them to develop a truer understanding of what they had seen. ("Students' Ideas in the Science Classroom", 1988. p. 4)

"It's not far off from our fifth graders," commented a fifth grade teacher who

had just gone through the experience with her class.

During December, the use of materials, time teaching science and use of ICM techniques were all within the goals established for the practicum. Only one teacher, a fourth grade teacher did not meet the time requirements. The fourth grade teachers continued their physical science and life science units. The fifth grade teachers presented life science units on animals without backbones which included classroom collections of shellfish and on plant communities which included sprouting lima beans, growing molds, meal worm observations and lessons on senses. The sixth grade teachers began units on the human body systems and winter ecology. With the contract negotiations resolved and final contract language approved, the third sixth grade teacher who was chief negotiator for the teachers, had time to begin learning and using the ICM. Again, very positive and excited comments were made from all the fifth and sixth grade teachers. Before the holiday break, one sixth grade teacher said, "Usually, things shut down around Christmas, but I haven't cancelled one science lesson."

Throughout the month of January 1988, seasonal science activities were developed which took advantage of the New Hampshire snow. In an earth science unit in fourth grade, "snowflake science" from the "Hands on Science" section of Instructor was introduced. (Markle, 1987). Winter ecology was taught in the sixth grades and included trips to the science center for snowshoeing and tracking activities. The fifth grade students continued to experiment with mealworms in the life science unit and electricity in the physical science unit. The students used their logs to record observations of fishtank behaviors. All of the classes met their time requirements and recorded increased usage of audio-visual materials, measurement tools and use of kits.

In February, the fourth grade students continued their study of machines

and pulleys. The fourth grade teachers told the principal that they were pleased with the ICM, the new textbook and all the materials, but they were having trouble using the log effectively. One teacher said that she was using the mapping activity introduced at the Paratore workshop instead of individual logs. Another fourth grade teacher stated "Some of our kids just don't write well enough to use them independently." The other fourth grade teacher said that she was using them only for some of the experiments.

In the sixth grades, the students continued their study of winter ecology and the human body systems. The teachers reported positive student interactions with the materials. Even though there were several days cancelled due to snow storms, all of the teachers were able to meet their time requirements for the three weeks before winter vacation.

The fifth grade teachers completed life science units on animals with backbones and the senses. They used ICM in the tasting, touching, and hearing objects. They used graphs to record the time versus the number of people identifying a smell while they were blindfolded. The teachers recorded an increased use of kits and audio-visual materials during the month, and were able to meet or exceed all weekly time requirements.

In March, as a result of grant written by the principal, one teacher in fourth, fifth and sixth grade became involved in using laser discs in their classroom. Although the grant had been received a few months earlier, equipment, and discware had not arrived in sufficient quantities to begin training. As a part of the grant, each of the teachers received an Apple II-GS computer, a laser disc player, a 25" color monitor, and authoring software intended to allow the computer and disc player to interact. In addition, the principal of Beaver Meadow along with one other principal who was cooperating in the project, purchased several laser discs. In March, science discs began

arriving. One set of two discs was especially interesting to the teachers because it covered most of the earth science units in the new science curriculum (Elementary Earth Science, 1988). On March 31, the three involved teachers and principal attended a training session on using computers to direct the sequence of information stored on the discs.

In the fourth grades, the students studied weather. The new laser disc contained a sequence on weather which included dramatic footage of tornadoes and thunder storms. The teachers and students were very excited about the new discs. In addition, the classes traveled to the science center for a physical science unit on machines. The teachers recorded increases in time spent on science each week. As a result, March became the first month in which all of the fourth grade teachers met or exceeded their time requirements in science each week.

In the sixth grade, the teachers continued lessons on the human body system and began the "family living" unit which introduces students to the human reproductive system and communicable diseases. One teacher stated that she needed to use the heredity unit in the textbook and suggested that it be a required unit at this grade level.

In April, the fourth grade teachers continued the weather unit and began the physical science unit on friction. One fourth grade teacher registered a concern with the principal.

> This machine unit seems to have taken forever because I've never taught it before and it takes more time to discover what works well and what doesn't. I've really tried hard to cover the text and include ICM but it's very time consuming. I'm not sure I'll cover all I'm supposed to this year. I feel as though I have to decide whether to either do a cursory job covering all the required units or cover less information, but more thoroughly. I'm not sure which is better, but I am choosing the latter this year.

In contrast, one other fourth grade teacher said, "I'm doing everything ICM."

She added that she was having no trouble covering the material, but found that she was using the observer log less and less. The other fourth grade teacher, the one who did not lead the workshops stated that she was also uncomfortable with the observer log. She also stated that she was using the textbook less than she had anticipated. All of the teachers continued to use the laser discs on weather. In addition, the fourth grade teachers met with the science center staff to complete plans for the coming year and to share some lessons on pulleys and simple machines.

In the fifth grade, the teachers held a science fair. The students used the new materials to create presentations of some aspect of science that they had studied during the year. The projects included volcanoes, fish, shells, minerals, plants, snakes and other live and child-made displays. The parents were invited to attend the displays during the week before spring vacation.

In the sixth grades, the teachers continued units on the human body and on heredity. On four occasions, local physicians came into the classrooms to make presentations, lead discussions, and answer questions about sexually transmitted diseases and human reproduction. Filmstrips and movies supplemented the units. Although some of the lessons had been taught before, the teachers stated that the new curriculum, especially the unit on heredity, was helpful in presenting the lessons.

The principal distributed two articles on science to the teachers. The first reported on the progress of the new initiatives from the National Science Foundation (Landes, et al, 1988). The second article supported the hands-on approach in elementary science education (Kotar, 1988). Although, no formal time was set aside to discuss these articles, one teacher did comment that she enjoyed all of the articles that the principal shared with the staff.

In May, the fourth grade teachers concluded their presentation of simple

machines. All three teachers continued to use the observer log less frequently, or not at all. Each continued to record frequent use of the kits, measuring instruments, and the ICM, but only one of the three teachers met the time expectations. The two teachers who did not meet the time requirements began a pilot program in reading which involved the entire morning of every day. One of the two teachers was involved in the laser disc project, and although the focus of the laser project was on science, several workshops were scheduled for her and the two other participating teachers.

The fifth grade students studied oceanography. Materials for the textbook were supplemented by materials from the science center, the kits and laser discs and video tapes on whales and other sea life. The culminating activity was to participate in a whale watch on the ocean. The teachers used the ICM in the preparatory lessons and the discussion techniques learned in the colloquium during and after the whale watch.

In the sixth grade the teachers completed units on the changing earth and began to prepare their students for the end of the year. During the second week in May, one sixth grade teacher had to leave the school for an operation, and was absent for a month. The other sixth grade teacher helped the substitute teacher with a review of the concepts introduced during the year. Only the experienced sixth grade teacher was able to meet the time expectations for May, however. Much of the substitutes time was spent on other subjects.

During the first week in June, the teachers administered the post-test in science. The sixth grade teacher who had been out during most of the month of May, delayed giving the tests to his class until his return during the second week in June. The sixth and fifth grade teachers reported no difficulties in administering the test. They said that the students seemed to perform

reasonably well.

The fourth grade teachers were disappointed with their students results. In one conversation with the principal, one of the fourth grade teachers said

> Well, the results are not as high as I'd hoped. The students seem to come with a lot of knowledge about machines and also about plants and animals, but of the three units, I felt I did the best teaching about weather, using all the suggested experiments, the laser disc, and always ICM. However, I also felt that during our review time last week, the class had least retained concepts about weather. My reaction is that weather is not part of a 10-year-old's world- other than whether it's sunny or not. They are certainly capable of learning those concepts, but maybe not hold them, especially regarding highs and lows and atmospheric pressures. Even though the results are not what I'd anticipated, I do feel the Holt book is a good one.

She had hoped that her students could average 80 percent, but only achieved 75 percent. Although she was the most expressive about her disappointment, the other two teachers indicated some regrets as well. One reiterated an earlier concern about whether she had taught some things in too much depth at the expense of other concepts. The other teacher stated that she believed that the students would achieve at a higher rate once she and they were more familiar with the materials, techniques and textbook. None of the teachers suggested that the test was an inaccurate reflection of their students' achievement.

District Participation

District participation in the practicum followed a similar pattern to its implementation at Beaver Meadow School, but at a reduced rate. All schools administered some pre-tests at the beginning of the year. All textbooks, kits and apparatus were introduced at approximately the same time. But training in the ICM occurred later at the other schools.

While the pre-tests in science were being administered at Beaver Meadow in October 1987, the tests were distributed to other schools in the district. The Beaver Meadow principal requested that the principals of other schools ask

their teachers in grades four and five to administer the assessments for baseline data on student achievement. The sixth grade assessments were being reprinted due to some errors in printing. Many of the principals were reluctant due to the increased tension caused by the prolonged teacher negotiation. After much discussion, all the principals agreed to administer the assessments in grades four and five. They requested that the grade six assessments not be sent due to the contract dispute. The Beaver Meadow principal agreed not to send the sixth grade assessment.

On December 1, 1987, the four Beaver Meadow teachers who had volunteered to do the teacher training, the science center staff member, and the principal met with the science committee. The grade four teachers and the science center staff member presented the ICM and answered questions about it from others who had less recent experience and were less familiar with it. At the meeting, it was decided that each person who was familiar with the ICM would be paired with a member of the science committee who was less familiar with the technique. The groups of two or three teachers would then be responsible for training the other teachers at their grade level. The training schedule was revised with the initial training to begin in January, and the final session ending in the middle of February. The teachers agreed to meet on their own to prepare the lessons, try them on their own students and revise as needed. The teachers were enthusiastic. They seemed eager to be learning the ICM, working together, and planning for the inservice sessions. The science center staff member was able to answer many of the questions concerning the facilitation of the colloquium. During the model lesson, teachers seemed to experience difficulty in playing a non-judgmental role. "We are here to keep the discussion going, to redirect the conversation, and to pose questions which help to focus the discussion," she said, "But the hardest part is to let them

come up with the answer, the way real scientists do. If everyone's meal worms decide to love the taste of vinegar on this particular day, their conclusions that meal worms like vinegar is valid for this time and place. It just takes some time getting used to letting them come up with the answers."

In January 1988, the Beaver Meadow School teachers who had volunteered to train other teachers continued to meet with their science committee partners to prepare for the workshops. To prepare the district teachers for the workshops, an agenda was mailed to every elementary teacher in the district (Appendix E:140). The agenda was prepared by the science committee, the science center staff, the Beaver Meadow teachers and the Beaver Meadow Principal. In it the presentations and issues for discussion were outlined and the workshop schedule was listed. In addition, the new philosophy for science education was articulated and the decisions for the future were addressed.

The first grade-level meeting was for third grade teachers and was held on January 11. It was attended by all third grade teachers in the district, the Beaver Meadow teachers who were training other teachers and the Beaver Meadow School Principal. Although the first workshops were for the primary grade teachers, Beaver Meadow School teachers attended all the workshops to add support and to learn for their colleagues. In this workshop, the ICM was presented by members of the science committee and the science center staff. The ICM was introduced through the use of mealworms. It followed a similar format to one presented by the fifth grade teacher at Beaver Meadow School (Appendix F: 145). Having the Beaver Meadow Teacher attend the meeting seemed to be helpful for she answered many questions during and after the colloquium. At this and subsequent sessions, the participants recorded their evaluations of the session on a "Science In-service Feedback Form" (For a copy and responses see Appendix G:153). The comments were very positive. The

teachers expressed their eagerness to learn more about the ICM and to share more by agreeing to meet again in March. The teachers liked the ICM and wanted to work with it in depth. The only need expressed was that more materials be provided in the kits. Apparently, some teachers were unaware that they could request as many materials as they wished for their classes.

The grade-level training sessions for kindergarten, transition, first and second grade teachers followed a similar format and experience. All of the Beaver Meadow teacher- trainers and the principal attended each session. Although teacher attendance at the first session was required by the district, each group decided to meet at least two to three more times during the school year. The sessions served to reinforce the belief that the ICM was an appropriate method of instruction and that the new curriculum and materials were appropriate.

On January 25, the training session for grade 5 was held. Although it was not reflected in the feedback sheets (Appendix G:153), the session was not positive. The fifth grade teacher at Beaver Meadow School and her partner, a science committee member from another school, prepared a physical science lesson on electricity and circuitry. Since she had just completed a unit on the same topic with her class at Beaver Meadow, and since the third grade teachers had just completed a unit on mealworms, she decided to present the physical science unit. The investigation and colloquium portion of the lesson went well.

When the decision and planning for the future section began, however, the teachers began complaining about the new curriculum. Several teachers felt that they should be able to teach the same topics as in previous years. One stated, "Now the sixth grade teachers have all the good topics. There's nothing interesting for us to teach." Another teacher added, "Why can't we switch with the sixth grade? They taught some of this last year." The assistant

superintendent who attended this and parts of the previous sessions tried to reassure teachers, but several continued to voice objections. After the session the principal met with the assistant superintendent, the science center staff, and the workshop presenters. As a result, the group agreed to produce more activities to support the fifth grade curriculum. The group also concluded that part of the concern may have been simply a resistance to change. "I'm surprised that we haven't seen more of it." suggested one teacher.

On January 27, the training session for sixth grade teachers was held. The sixth grade teacher at Beaver Meadow chose a unit from one of the originators of ICM called "What 's in the Bag?" (Lansdown, 1971). In it the participants are to guess what materials are in a brown paper bag. The contents of the bag, an apple, an onion and a tennis ball were taped together and placed in a plastic bag. The bag had then been rubbed with orange peels. The ICM was then conducted in several abbreviated sessions involving first observations only, and then passing the bag around the colloquium circle, to finally allowing the participants to squeeze, bounce and otherwise experiment with the bag. The only thing not allowed was to open the bag. The teachers appeared to enjoy the session and discussed several topics related to the activity which face scientists as they experiment with the unknown. One teacher asked "What if the contents had been alive? It wouldn't have lasted long after we bounced it so hard." After incorrectly guessing that one of the objects was an orange, one of the teachers said "I guess scientists have misleading clues in their experiments too". When the workshop leader said "Now, if I were doing this the way George Tokieda would like us to do, I would never open the bag. But I didn't have the courage to do that with my class or with you." Several teachers assured her that she was wise not to try it. During the planning part of the workshop, one teacher commented that she wished she could continue to

do all the exciting things she did last year," But are now only for the fifth grade." All of the workshop leaders who had been at the fifth grade meeting two days before looked at each other and smiled. Plans for sharing between the fifth and sixth grades were set and meeting dates scheduled.

In February, the fourth, fifth and sixth grade training sessions were held. At the fourth grade meeting on February 8, the two Beaver Meadow School teachers presented an activity from the textbook using the ICM. They had been very nervous in anticipation of their presentation. Initially, they had asked for more time to prepare. Then, due to the teacher negotiations, the sessions were postponed. Reading workshops and a school cancellation due to a snow storm in January had further delayed their workshops. By the time their workshop time arrived, they had spent over 100 hours in preparation. The figure did not include time spent with their students refining the lessons. The teachers at the workshop responded very positively to the session (Appendix G:153). As occurred in the other workshops, the teachers wanted to meet again, were encouraged by the demonstration and seemed to appreciate all the efforts that went into the lesson. The two fourth grade teachers stayed after the 5:30 pm ending time to continue discussions with interested teachers.

In March 1988, the fifth grade teacher at Beaver Meadow School who had led the workshops was also the teacher selected to participate in the laser disc project met with the science center staff and a few other teachers to prepare materials for the grade level (Appendix H:169). The group accomplished many of the tasks which were unresolved at the January meeting. They shared with each other their work to date and offered to help other teachers. In addition they planned a heredity unit identified projects to extend to lessons in the textbook.

At Beaver Meadow, the teachers read and discussed two articles

distributed by the principal which reaffirmed the objectives of the practicum The first article described the need for an extended inservice training for teachers (Kyle, et al, 1988). The second urged teachers to ask more questions and give fewer answers (Yager, 1988). The teachers' comments indicated agreement with the articles. One teacher stated, "It would be nice if we can continue these grade-level meetings throughout the year next year."

In May, the principal sent a message to all principals requesting that post-test assessments occur during the first week in June. The response from the other principals was mixed. Some had questions about the use of the data. One asked for clarification about how the results should be reported. Another refused to give the grade four and five assessments arguing that his teachers did not have enough time to implement the curriculum and therefore the results would not be valid. He did offer to administer the sixth grade assessment as a baseline for that level.

During the last two weeks in June, the principal distributed an end of year survey to all the elementary science teachers in Concord (Appendix I:175). The survey was intended to provide the principal with information for identifying strengths and weaknesses in the curriculum, to allow for corrections in the curriculum, to provide teachers with an opportunity to comment on their needs, to obtain data for planning future inservice activities, and to document the degree to which the curriculum was implemented. For the purposes of this practicum, the survey served to document practicum goals for Beaver Meadow Teachers and allowed for comparisons among the schools in Concord.

Also in June, the principal received post-test scores from two of the other schools. The principal of one school had a heart attack and no tests were administered. Another principal stated that he forgot to give them. The results from the other two schools reflected modest gains in achievement, but

not as large as the gain recorded at Beaver Meadow School.

Function of the Writer

The writer was principal of Beaver Meadow School and chairman of the science committee. As such, he played an important leadership role in the implementation of this practicum. Not only did he provide encouragement, and support for the target group teachers, he was responsible for leadership among other district principals, the science committee, and the science center staff as well. When it appeared that the teacher contract dispute would endanger the implementation of this practicum, he recruited the science center staff to be the initial teachers of the ICM. When the contract negotiations were completed, he expanded the group of teachers from the original plan of only Beaver Meadow School teachers to include the science committee and science center staff. He was responsible for insuring that the district's money was well spent. As principal, he recruited teacher instructors, oversaw the ordering of materials and scientific apparatus, and the creation of appropriate materials. He encouraged the use of homemade manipulatives, and other activities which supported the curriculum. He made sure that all appropriate faculty members were involved in the program.

The writer was responsible for written communications to faculty members, the science committee, the science center staff, the other principals and the district administration. When the teacher negotiations were unsettling to many teachers, the writer maintained a positive attitude and a supportive atmosphere. The writer involved the teachers in decision-making within the project, which included serving on a validation committee to review pre-test and post-test questions. He was also responsible for designing the end of year and monthly survey forms, as well as the inservice feedback form.

Monitoring The Action

Several formal and informal mechanisms for monitoring the progress of the practicum were created. The primary source of information was the informal discussions between the principal and the Beaver Meadow staff. In addition, time was set aside for feedback during several staff meetings. Monthly surveys were completed by each teacher, as well as a summative end-of-year survey of all elementary science teachers in the district. Inservice feedback forms also provided necessary information for planning and refining aspects of the curriculum and instructional process.

The assistant superintendent of schools for curriculum development in Concord was a primary reader/observer for the project. He provided feedback to encourage, direct, and correct the writer as appropriate. He provided financial support for the purchase of materials and for inservice expenses. In addition, one elementary school principal in Concord was a reader and an observer. She supported the project by providing critical feedback and the perspective of one who administered a school with similar low scores in the area of science. She was also interested improving the science program within her school. The third observer/reader provided the perspective of a current member of the Concord Board of Education. As a former high school science teacher, he brought that additional perspective.

Rationale For Design Elements

The state-wide administration of the CAT in 1985-86 and 1986-87, and the dissatisfaction among teachers with the existing curriculum, led to the selection of improved achievement in the science and teacher training in science as an appropriate focus for this practicum. Prior activity established concern with

the topic and pointed to suspected causes for the low performance. The availability of annual standardized data was a strong factor in the confirmation of science as an area of weakness. Since the New Hampshire State Department of Education made a multi-year commitment to state-wide standardized test administration and analysis, the writer believed that the effectiveness of the project could easily be evaluated not only at the conclusion of the practicum, but each year. The future data would automatically be provided without internal test development or additional requirements of staff. Since the pre-test and post-tests used during this project were designed as an item-by-item parallel to the curriculum, measurement of future achievement in science was possible.

Analysis of the literature, teacher surveys, and the previous training and program development with regard to student achievement in science pointed to several possible interventions for improvement. Having reviewed among other strategies, the role of the principal and various components of instructional methodology, the decision was made to focus on the provision of information on use of manipulatives and the importance of verbalization, as well as training in all the necessary aspects of instruction. This focus allowed the entire teaching staff to be trained as a unit, a model which worked well on prior occasions. It enabled the development of total school support for the project, which encouraged commitment and decision-making by the whole staff. The project was more likely to be sustained if the staff identified the needs, helped to develop the activities to address the needs and participated in the evaluation of academic growth.

Chapter 6

EVALUATION

Measurement

The primary instrument for measuring student and program success was a test created by the principal and staff of Beaver Meadow School from end-of-chapter and supplemental units tests published by Holt, Rinehart and Winston, the publisher of the adopted textbook and kit materials. The test was created in the fall of 1987 to identify progress in implementing the newly created science curriculum. The principal was responsible for gathering the evaluation materials and for selecting questions from the test publisher which measured units in the textbook required by the curriculum. Teachers at Beaver Meadow school analyzed the bank of questions and made recommendations for changes in the test questions.

Test validity was established in several phases. Initially, the writer and the advisor for this practicum reviewed the test and omitted ambiguous questions. Before the test was administered, the teachers in grades 4-6 at Beaver Meadow School examined the assessments and determined appropriateness of the questions for their grade level. Finally, the coordinator and program assistant at the science center reviewed the content of the questions for relevance and appropriateness.

Other measures of program success included surveys designed by the principal to assess progress in implementing the process objectives of this practicum. One survey was completed monthly from October 1987 to May 1988 by the teachers in the target classrooms (Appendix C: 137). In it teachers were asked to document time spent teaching science and use of materials and

techniques employed in this practicum. All of the teachers in grades 4-6 at Beaver Meadow School completed the surveys for all of the months indicated. The information provided in the surveys was verified during the principal's classroom observations and served the function of monitoring practicum activities by alerting the writer to problems not observed during observations or meetings.

Another teacher survey was administered at the end of the practicum (Appendix I:179. The survey was designed by the principal to assess teacher attitudes, accomplishments and needs as they relate to the science curriculum. As chairman of the science curriculum committee, the principal used the information to plan for the 1988-89 school year's inservice needs, and to report to other principals and central office administration about the progress and results of the curriculum implementation. The survey was sent during the last two weeks of school to all teachers in grades K-6 who received training and used all or parts of the curriculum materials and techniques during the 1987-88 school year.

Analysis of Tabulated Data

The tabulated data will be discussed by objective and by grade in the sequence listed in the objective.

Table 8

Results of Pre-Test/Post-Test-Grade 4
Beaver Meadow School-1987-88

	Pre-test	Goal	Post-Test	Difference
Earth Science	31%	61%	64%	+ 3%
Physical Science	28%	58%	81%	+23%
Life Science	33%	63%	73%	+10%
Total*	30%	60%	72%	+12%

Table 8 indicates the data for the fourth grade at Beaver Meadow School. The objective was to improve pre-test scores in each of the curriculum strands and in total by 30 percentage points. There were 11 questions relating to earth science and 9 each relating to physical and life sciences on the test. The overall achievement gain was 42 percentage points. This represented a gain from a pre-test score of 30 percent to a post-test score of 72 percent, or 12 percentage points higher than the targeted goal.

In earth science, the students improved their performance on the post-test by 33 percentage points from a score of 31 on the pre-test to a 64 on the post-test. This represented an improvement of 3 percentage points above the targeted goal. The goal for this objective was met.

On the physical science portion of the test, the fourth graders improved their scores by an average of 53 percentage points from a pre-test score of 28 percent to a post-test score of 81 percent. This reflected a gain of 23 percentage points above the targeted goal of 58 percent. Therefore the goal for this objective was achieved.

On the life science portion of the test, the goal was to improve the average pre-test score of 33 percent to 63 percent on the post-test. The results indicated an average score of 73 percent which was an improvement of 40 percentage points above the pre-test and 10 percentage points above the targeted goal. The goal for this objective was obtained.

The data suggest that even though students in grade 4 met the goals of the objective, achievement in earth science was the weakest of the three areas in the science curriculum. These results were confirmed by the fourth grade teacher who believed that even though the weather unit represented her best teaching, the students did not retain the concepts as well as they had in other physical and life sciences. The 33 percent improvement in the score for earth

science was probably due to a combination of factors. Given the previous statement, the teachers' efforts to implement successfully each component of the ICM may have overcome much of the students' lack of knowledge or sense of relevance of the weather unit. The audio-visual material, especially the laser disc on weather undoubtedly stimulated interest in the subject and contributed to the students interest in the lessons.

The 53 percentage point gain in physical science represented the largest gain in any of the three areas. Several factors contributed to the students success. There were many materials in the kits relating to the physical sciences. The teachers used the ICM successfully in their lessons. In addition the machine unit was taught in the late winter and early spring, so the subject had been taught to the students more recently.

The 40 percentage point gain in life sciences represented knowledge retained over the longest period of time. The life science units were taught by the fourth grade teachers in the fall. The teachers' use of ICM, the students' interest in the hawk and other units, and the students' own relatively strong background in this area were contributing factors to the achievement success.

Table 9

Results of Pre-test/Post-test-Grade 5
Beaver Meadow School-1987-88

	Pre-test	Goal	Post-Test	Difference
Earth Science	46%	76%	81%	+ 5%
Physical Science	40%	70%	72%	+ 2%
Life Science	39%	69%	90%	+21%
Total	42%	72%	77%	+ 5%

Table 9 indicates the data for the fifth grade at Beaver Meadow School.

The objective was to improve pre-test scores in each of the curriculum strands and in total by 30 percentage points. There were six questions relating to life science and nine each relating to physical and earth sciences on the test. The overall achievement gain was 35 percentage points. This represented a gain from a pre-test score of 42 percent to a post-test score of 77 percent, or 5 percentage points higher than the targeted goal.

In earth science, the students improved their performance on the post-test by 35 percentage points from a score of 46 on the pre-test to a 81 on the post-test. This represented an improvement of 5 percentage points above the targeted goal. The goal for this objective was met.

On the physical science portion of the test, the fourth graders improved their scores by an average of 32 percentage points from a pre-test score of 40 percent to a post-test score of 72 percent. This reflected a gain of 2 percentage points above the targeted goal of 72 percent. Therefore the goal for this objective was achieved.

On the life science portion of the test, the goal was to improve the average pre-test score of 39 percent to 69 percent on the post-test. The results indicated an average score of 90 percent which was an improvement of 51 percentage points above the pre-test and 21 percentage points above the targeted goal. The goal for this objective was obtained.

The results for life science represented the largest gain of any of the three areas of science. Certainly, the students interest was spurred by the mealworm and whale projects. The kits, measuring materials and audio-visual materials, especially some of the laser discs added to their interest. Observer logs were used consistently at this grade level and the ICM was implemented early and consistently. Gains in other areas reflected the teachers support for the project, their ability to master the techniques, and their establishing

science as a high priority in their classroom.

Table 10

Results of Pre-test/Post-test-Grade 6
Beaver Meadow School-1987-88

	Pre-test	Goal	Post-Test	Difference
Earth Science	35%	65%	78%	+13%
Physical Science	42%	72%	83%	+11%
Life Science	47%	77%	83%	+ 6%
Total	41%	71%	82%	+11%

Table 10 indicates the data for the sixth grade at Beaver Meadow School. The objective was to improve pre-test scores in each of the curriculum strands and in total by 30 percentage points. There were 11 questions relating to life science and 9 each relating to physical and earth sciences on the test. The overall achievement gain was 41 percentage points. This represented a gain from a pre-test score of 41 percent to a post-test score of 82 percent, or 11 percentage points higher than the targeted goal.

In earth science, the students improved their performance on the post-test by 43 percentage points from a score of 35 on the pre-test to a 78 on the post-test. This represented an improvement of 11 percentage points above the targeted goal. The goal for this objective was met.

On the physical science portion of the test, the fourth graders improved their scores by an average of 41 percentage points from a pre-test score of 42 percent to a post-test score of 83 percent. This reflected a gain of 11 percentage points above the targeted goal of 72 percent. Therefore the goal for this objective was achieved.

On the life science portion of the test, the goal was to improve the average pre-test score of 47 percent to 77 percent on the post-test. The

results indicated an average score of 83 percent which was an improvement of 36 percentage points above the pre-test and 6 percentage points above the targeted goal. The goal for this objective was obtained.

Solid gains in achievement were evident in each area of science. Factors which contributed to the success included the use of materials, the use of ICM and the cooperative attitude in evidence throughout the practicum. The one teacher who served as a teacher trainer was enthusiastic throughout the practicum. Her positive attitude, encouragement and leadership may have helped the other teachers learn about the intervention strategies employed in this practicum.

The goal for the first process objective was to teach science for an average of 150 minutes each week. This goal was established to comply with the New Hampshire State Department of Education's guidelines for teaching science in the intermediate grades. To attain the goal, the fourth grades had to increase the average amount of time spent on science by 50 minutes. The fifth grades needed to increase the average amount of time spent on science by 70 minutes, and the sixth grade needed to increase the time by an average of 75 minutes.

Table 11

Comparison of Average Minutes/Week Teaching Science
Beaver Meadow School- By Class 1986-87 With 1987-88

	Average Minutes/ Week/ Teacher			
Grade	1986-87	Goal	1987-88	Difference
Fourth	100	150	139	-11
Fifth	80	150	154	+ 4
Sixth	75	150	195	+45

Table 11 indicates the comparison of times spent teaching science during

the 1986-1987 school year with the 1987-1988 school year. In grade four, the average amount of time increased by 39 minutes over the previous year. This represented an average of 11 minutes less than the targeted goal. In grade five, the average amount of time spent teaching science increased by an average of 74 minutes each week, which was 4 minutes above the targeted goal. In grade six, the average amount of time increased by an average of 120 minutes each week. This total was more than double the previous year's total, and was an average of 45 minutes about the targeted goal.

The goal for the second process objective was to improve over the previous year in the indicated amounts the percent of curriculum objectives completed by each grade. Table 12 indicates the results for this objective.

Table 12

Comparison of Objectives Completed in Science- Grade 4-6
Beaver Meadow School- 1986-87 with 1987-88

	1986-87	Goal	1987-88	Difference
Grade 4				
Earth Science	100%	100%	83%	-17%
Physical Science	45%	80%	100%	+20%
Life Science	66%	90%	89%	- 1%
Grade 5				
Earth Science	80%	100%	100%	+ 0%
Physical Science	45%	90	100%	+10%
Life Science	40%	80	100%	+20%
Grade 6				
Earth Science	80%	100%	100%	+ 3%
Physical Science	20%	70%	100%	+23%
Life Science	100%	100%	100%	+ 0%

In grade four, all of the objectives for physical science were completed. In the area of life science, eight of the nine units were completed for an average of 89 percent. This percent represented an increase from the previous year in which only two-thirds of the objectives were met. It is also only one

percentage point away from the goal of 90 percent. In earth science, five of the six units were completed which was a decrease of 17 percentage points from the previous year in which all of the objectives were completed.

It is interesting to note that the deficits both occurred in the same classroom. The teacher in this classroom had not taught fourth grade since the 1973-1974 school year. Therefore she had to learn all the curricula areas. The other two fourth grade teachers were teacher trainers and were more thoroughly involved in the practicum activities.

When compared to the amount of time spent teaching science, the fourth grade teachers were the only ones who did not meet the time guidelines. Although the deficit in time spent on science was not isolated to the one classroom in which the teacher was new to the grade level, of the three teachers, she spent the least amount of time on science. In addition, of the three classes, her students' scores were the lowest in achievement.

Among the fourth grade students, there appeared to be a correlation between achievement and the time spent on science and the objectives completed. When the achievement scores of the three areas of science were compared, the fourth grade students performed less well on the life and earth science sections of the test. Even though the achievement objectives were met, it was likely that the scores for grade four would have improved even more than they did had the the process goals been attained.

In grades five and six, all of the objectives were completed in every area. These results were consistent with the large increases in time spent on science indentified in Table 11. They also support the consistent results achieved in objective one (Tables 8-10). The objectives for grades five and six were therefore attained.

The goal for the third process objective was to increase by the indicated

amounts the use of materials and techniques employed as a part of the intervention strategy of this practicum. Table 13 indicates the results for this objective.

Table 13

Comparison-Classroom Use/ Month of Materials/Techniques- Grades 4-6
Beaver Meadow School- 1986-87 with 1987-88

Material/Technique	1986-87	Goal	1987-88	Difference
Kits/Manipulatives	0	5	8	+ 3
Measuring instruments	1	5	9.8	+ 4.8
Observer Logs	0	2	4.1	+ 2.1
Audio-Visual Material	*	3	7.3	+ 4.3
Textbooks	*	5	10	+ 5
Formal Verbalization	*	3	7	+ 4
Grade 5				
Kits/Manipulatives	0	5	8.5	+ 3.5
Measuring instruments	1	5	8.3	+ 3.3
Observer Logs	0	2	3.1	+ 1.1
Audio-Visual Material	*	3	7.6	+ 4.6
Textbooks	*	5	11	+ 6
Formal Verbalization	*	3	5.3	+ 2.3
Grade 6				
Kits/Manipulatives	0	5	8.6	+ 3.6
Measuring instruments	1	5	8.8	+ 3.8
Observer Logs	0	2	1.5	- 0.5
Audio-Visual Material	*	3	6.9	+ 3.9
Textbooks	*	5	11.6	+ 6.6
Formal Verbalization	*	3	7.1	+ 4.1

*= less than once/ month

The tabulated data document the achievement of the process objective in the use of Kits, manipulatives, measuring instruments, audio-visual material, the textbook, and the formal verbalization of the ICM in each of three grades. The results support the information reported in Chapter 5 which identified the specific materials and techniques used in this practicum. The frequent use of all the materials and techniques listed above were a substantial contribution to the successful attainment of all of the achievement objectives for this

practicum.

The only area in which the third process goal was not achieved was in the use of the observer log. The goal was to use the observer log an average of two times each month. In grade six the average was one and one-half times a month. This represented an average of one-half of a time less than the targeted goal. Part of the low frequency in this area was due to the fact that one sixth grade teacher was absent for one month during May and June. There was however, infrequent use of the observer log by one of the other sixth grade teachers. Even though the third teacher in the sixth grade attained the goal, the frequency of use was not enough to overcome the deficits in the other two classrooms.

Although the fourth grade teachers met the stated goal in the use of observer logs, the data is misleading. From October to January, the fourth grade teachers used the observer log frequently. From February until the end of the school year, the log was used less frequently. In fact, according to the monthly survey forms, no observer logs were used in the fourth grades during the month of May, 1988.

Therefore, even though the fifth grade teachers attained the goal, the impact of the use of the observer log is unclear. From the data presented and from the experience gained, its relationship to achievement as measured in this practicum does not support a conclusion of positive or negative influence. Since all grades met or exceeded the targeted goals, it does not appear to be a key factor.

Table 14 indicates a comparison of Beaver Meadow School results with the other schools in the district. Data were received from three of the five other elementary schools.

Table 14

Comparison of Science Scores-Percent of Items Correct-Grades 4-6
Concord With Beaver Meadow School

	Fall-1987	Spring-1988	Difference
Beaver Meadow			
Grade 4	30	72	+42
Grade 5	42	77	+35
Grade 6	41	82	+41
Concord*			
Grade 4	36	63	+27
Grade 5	41	63	+22
Grade 6	**	61	**

* Data collected from 3 of 5 elementary schools that took pre-test and post-test

** Pre-tests were not given in the sixth grade

In grade four, Beaver Meadow students improved an average of 15 percentage points more than the average for other fourth grade students in the district. In grade 5, the Beaver Meadow students improved by an average of 13 percentage points more than other fifth graders in Concord. In grade six, the post-test score for Beaver Meadow students was 21 percentage points higher than the comparison group of sixth graders.

The results suggest that the implementation of the ICM, the commitment of the teachers and the beneficial side effect of their leadership role in inservice training were significant. Since all schools received the textbooks, kits and support materials at the same time, the only variable for which data exists is the amount of time spent using the ICM. At Beaver Meadow, the four teachers who had received training the previous spring began implementing the ICM in October. Through their work to develop lessons, they improved their technique and shared their learnings with other Beaver Meadow teachers. This occurred before the January and February workshops when the other teacher in

the district who were not a part of the science committee were trained in the technique. The additional time spent using ICM may have helped to improve the student achievement scores at Beaver Meadow.

At the end of the 1987-1988 school year, a survey of teachers was conducted throughout the Concord School District (Appendix I: 175). From the data gathered, comparisons between the practices at Beaver Meadow School and other Concord schools were made (Table 15).

Table 15

Comparison-Time/Materials/Techniques- Grades 4-6
Beaver Meadow School With Concord-1987-88

	Beaver Meadow			Concord		
Grade	4	5	6	4	5	6
Time/ Week*	150	155	182	195	174	181
% of Units Completed	92%	100%	100%	90%	100%	95
% of Lessons ICM**	95%	58%	65%	38%	28%	32%

* Average amount of time each week teaching science/ classroom
**- After initial training in ICM

Beaver Meadow teachers reported that they spent less time on science in grades four and five than was reported by other teachers at that grade level. In grade six, the teachers reported a similar amount of time teaching science. In grades four through six, teachers reported a high degree of success in completing the science curriculum. However, Beaver Meadow teachers reported a higher use of ICM than teachers at their grade level.

From the data presented, time spent teaching science and percent of units

completed were not sufficiently different to explain the difference in achievement reported in Table 14. With the exception of grade six, teachers at other Concord Schools spent more time each week teaching science than at Beaver Meadow School, but all grades met the minimum guidelines established by the New Hampshire State Department of Education of at least 150 minutes each week. Therefore the data as presented for time teaching science and percent of units completed do not provide meaningful distinctions between the two groups of teachers.

The tabulated data do indicate differences between the amount of science lessons in which the ICM was used. Teachers at Beaver Meadow reported ICM use which ranged from a low of 30 percentage points higher than Concord teacher in grade five to a high of 57 percentage points higher in grade four. This difference may account for the higher degree of improvement on the science post-test.

Side Effects

The practicum intervention described in this report resulted in several side effects. While the practicum intervention directly involved the students and teachers of grades four, five and six at Beaver Meadow, all teachers in the school participated in the intervention. Specifically, all shared in the discussions of research and literature which was provided by the principal. Every teacher received the training in ICM and in the use of the new materials.

The techniques and interventions used in science encouraged teachers to apply the strategies to other subjects. As discussed in Chapter 2, teachers had been using hands-on and verbalization techniques in mathematics. During the year, teachers began to employ the techniques in reading and language arts lessons as well. They found word mapping and discussion activities in writing

and pre-reading to be consistent with the ICM approach.

Laser disc use and the practicum interventions were mutually reinforcing. The original intent of the laser disc grant application was to improve science and math achievement. Once the grant was approved and a more thorough evaluation of existing discware had occurred, it became apparent that few, if any, appropriate math discs were available for grades four through six. There were many appropriate discs from which to chose in science.

Although the target population for this practicum were the students and teachers at Beaver Meadow School, the teacher training component of this intervention had some unanticipated results. The grade-level meetings were the initial means of transmitting the knowledge of the ICM to teachers in the district. The popularity of this method resulted in several additional meetings being held by the teachers. In addition, it will be the method by which curriculum is introduced and extended in the future.

No negative side effects were observed. Complaints were made about the freguency and concentration of student testing. The reader will recall that standardized achievement tests and pre-tests and post-tests occurred at the same time as the assessments in this practicum. There appeared to be no long term effect of this criticism. In fact, one of the teachers who was most vocal against the testing at the beginning of the year, requested when asked at the end of the year, that the pre-testing and post-testing be continued.

Evaluating Management Effectiveness

Elements of the management design were established to provide a steady and accurate information flow to the writer, so that inferences could be made as to the day-by-day, month-by-month, and overall effectiveness of the principal/ writer. Such information provided feedback in a timely fashion so

that adjustments, additional data gathering and clarification discussions could be made during subsequent discussions with teachers, science center staff and administrators. High student and teacher interest in science and regarding the materials and techniques of the intervention suggested to the writer that the process goals as well as the achievement goals were being achieved.

The monthly and end-of-year surveys required teachers at Beaver Meadow to reflect on the strengths and weaknesses of the curriculum and inservice model. It also provided a means for documenting achievements related to project objectives. This represented a good source of information from which the writer could infer management effectiveness. All but one of the process goals were achieved, but the information relating to the unmet goal was recorded in the monthly surveys and observed in time for the writer/principal to react. After discussions in February and March, the writer determined that although the process goal may not be achieved in that area, the consequence would not hinder the overall intervention strategy. The writer interpreted such information flow and decision-making opportunities to be critical factors in managing the practicum activities.

Chapter 7

DECISION ON FUTURE

Maintain, Modify, Abandon

The positive results achieved through the intervention strategy dictate that the strategies used be maintained. The necessity to extend the intervention to other schools is warranted from the data.

Although the implementation of the ICM is well established in some classrooms at Beaver Meadow, it is not practiced by all the teachers. In an end of year survey, many of the primary teachers, one fourth and one sixth grade teacher reported that they would like additional training sessions in the ICM. The two intermediate grade teachers who indicated a desire for additional help, used the ICM but did not feel comfortable enough with the techniques to feel that they were implementing it to its fullest effect. Although she had attended the training sessions, one second grade teacher could not remember what "ICM" meant when it was requested on the survey form.

The need to extend the intervention to other schools is also evident. While the teachers' response was overwhelmingly positive towards all elements of the curriculum, textbook, instructional materials and strategies, not everyone was comfortable with or knowledgeable about the ICM. District teachers responded favorably to the grade-level meetings. The district committed itself to continuing them in science as well as in other disciplines.

Follow Up

Monitoring of the improved achievement in science needs to be continued. Documentation of practicum successes are expected to be confirmed by improved science scores on the CAT in the fall of 1988. But documentation of

the strategy implementation needs to continue at Beaver Meadow and should be monitored at all the schools. The end-of-year and monthly survey format will be maintained at Beaver Meadow and encouraged throughout the district. Pre-test and post-test instruments will be revised to reflect any changes in the curriculum.

Teachers at several grade levels decided to continue meeting after the 1987-1988 school year was completed. During the summer of 1987, the science committee identified science units in grades three through six which were required and which were optional for the 1987-1988 school year, but made no recommendations for kindergarten through grade two. To address these issues and to share information about the successes of the previous year, teachers in kindergarten through grade two scheduled meetings during the summer of 1988.

District administrators will receive extensive feedback about the survey results for their buildings. General results of district-wide concerns will be shared with all the elementary principals and with the central administration. Through this information exchange, any individual school adjustments or district-wide needs can be addressed.

The writer expects that the continued monitoring of student achievement in science, the refining of the curriculum and continuing administrative support for the interventions will result in achievement gains throughout the school district.

Dissemination

A review of the practicum findings was shared within the school population and with the parents. Training sessions were presented to all district teachers kindergarten through sixth grade who teach science. Plans were made to share the results of the practicum with the administration. In

addition, on two occasions discussions were held with New Hampshire State Department of Education consultants regarding progress and successes of this practicum.

Additional methods of dissemination need to occur. Within the target school and within the district, there is a need to continue staff training. Plans exist to accomplish this. Inservice sessions have been scheduled during the school year.

The training of staff who are new to the school and the district is also needed. To meet this need, there is a plan to train new elementary teachers during the week preceeding the first week of school. It is the principals' responsibility to communicate to each new staff member that the interventions employed in this practicum are effective and that one of the conditions of employment is to instruct students using these strategies. Since Beaver Meadow School has included at least two new staff members during each of the four years previous to this practicum, it is likely that this need will continue. This inservice activity will include a review of the research on effective strategies. Prominent among the readings will be Lansdown (1971) and Tokeida (1987) on the ICM, and Schunk's work on verbalization (1981).

The results of the practicum will be available through the professional associations of teachers, principals and superintendents. Each organization will receive a brief summary of the practicum for inclusion in their regular publication. The article will invite interested professionals to visit the schools to see the intervention strategies in action. This information will also be shared with the press as an item of interest for New Hampshire readers.

Conclusions

From the evidence presented, the writer concludes that the intervention

strategies employed in this practicum were effective in improving student achievement in science in grades four through six. Positive student and teacher comments and consistent use of the practicum strategies verify the success in achievement measured by the pre-test and post-test assessments. A combination of teaching technique grounded in research, a rich variety of curriculum materials and teachers commitment to the implementation strategies were, in the opinion of the writer, essential elements of the practicum.

The results of this project support the writings of Lansdown (1971) and Tokieda (1987) on the effectiveness of the ICM. The results serve to validate the importance of appropriate materials and of scientific technique reflected in the investigation portion of the ICM (Tokieda, 1987), (Driscoll, 1981), (Suydam, 1978), (Lansdown, 1971). The results support the work of Paratore, (1988), Tokieda, (1987), Schunk (1981), Lansdown (1971), and Vygotsky (1962) in the importance of verbalization to fix concepts in the learners mind.

From the data, one may infer that the high degree of commitment on the part of the principal/ writer and target group of teachers were contributing factors. Due to the lack of sufficient comparison data from other schools, the degree to which the principal's influence was a factor is not known. More support does exist for the conclusion that teacher commitment and contribution were key factors.

The results were inconclusive concerning which materials and techniques were most important. Since audio-visual, measurement materials, and other equipment were used consistently by all the teachers, there was no evidence to conclude that one was more effective than the other. The data suggested that the observer log was not a contributing factor to student achievement.

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